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Articles

Book Reviews

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In This Issue

"Hear one side, and you will be in the dark; hear both sides, and all will be clear." Haliburton

It is a rare treat in the editorial business when an issue can be devoted to a single topic. That is the situation we happily face. The three articles in this issue address the same question: has promotion and advertising increased the sales of dairy products? If the answer is yes, then by how much and which individual products have benefited the most? The answers to these and other queries lie within these covers.

Before proceeding, a little background may be useful to our readers unfamiliar with the history of generic promotion in the dairy industry. The 1983 Dairy and Tobacco Act authorized a national program for dairy promotion, research, and nutrition education as part of a comprehensive strategy to reduce milk supplies and increase consumption of milk and dairy products. The promotion program is designed to strengthen the dairy industry's position in the marketplace and to maintain and expand domestic and foreign markets for uses of fluid milk and dairy products that are produced in the United States. The Act created the National Dairy Promotion and Research Board and is funded by a mandatory 15-cent-per-hundredweight assessment on all milk produced in the contiguous 48 States and marketed commercially. About $220 million is collected annually under the program.

Additionally, USDA is required to submit a report to Congress each July 1 containing an independent evaluation of the effectiveness of the dairy advertising program. The research reported in this issue was commissioned by the USDA Evaluation Committee for Dairy Promotion as part of an effort to enhance the evaluation process.

In the first article, Kaiser, Forker, Lenz, and Sun develop and estimate a disaggregated econometric model of the dairy industry. The model specifies three market levels (retail, wholesale, and farm) and four products (fluid dairy, frozen dairy products, cheese, and butter). The econometric results are used to simulate the impacts of a generic advertising program on the demand for milk and dairy products and farm and consumer prices. Their results suggest that at the retail level, the demand for fluid milk and butter increased modestly because of the program. Cheese demand also increased marginally while the demand for frozen products actually declined slightly because of price increases that outweighed advertising effects. They conclude that the program increased farm milk prices by 2.2 percent and has been an effective vehicle to increase retail demand and farm prices while reducing cheese and butter purchases by the government.

Wohlgenant and Clary take a different approach than Kaiser and company. They develop a model consisting of an industry-derived demand equation for milk at the farm-level linking advertising and government purchases to farm price, and a government-purchases equation linking advertising and support prices to government purchases. Their preferred two-equation model was estimated using disaggregated manufactured-product advertising. Their bottom-line results indicate that producers receive an average of $2.04 for each additional dollar spent on advertising. The authors note that this return may be on the high side because it does not take into account any supply response by farmers that may occur.

Our third article by Cox and Cornick is more methodologically focused than the others. They contend that in markets with controlled prices, such as in the dairy sector, econometric analysis is more complex than when prices are competitively determined. With controlled prices, econometric and statistical models require more advanced estimation techniques involving limited or censored dependent variables. They proceed to evaluate and compare different estimation methods for systems of simultaneous equations with censored dependent variables. The authors conclude that their proposed econometric techniques may not be necessary to model the dairy sector. They found that conventional estimation techniques introduce a minimal level of bias in the parameter estimates. The last chapter on this line of research has yet to be written.

In the first of three reviews, Gene Wunderlich gives the Paul Gates book *Land and Law in California: Essays on Land Policies* two thumbs up. According to Wunderlich, the book contains an "exceptionally rich source of background on California's agricultural landholding" which suggests "some origins of present landownership and agricultural production patterns." He also notes that the link between conditions in today's California agriculture and past policies and practices may not be completely direct, but who knows what small event of yesteryear has a profound influence today.

Wunderlich strongly suggests that this book has much knowledge to dispense and reading it would be a wise investment for those with an interest in land policies.

M.C. Hallberg's book, *Policy for American Agriculture: Choices and Consequences,* is "aimed at providing the basic tools and information needed for future agricultural policy analysis and development." However, because the book is targeted to undergraduate students and perhaps as an introductory text for graduate-level classes, its reviewer, Sam Evans, finds little new in content or presentation. Nevertheless, Evans finds the book a useful reference for anyone interested in learning about the development and scope of U.S. agricultural policy. Overall, Evans thinks the author does a "workmanlike" job throughout the book with a few errors of commission and omission.

Agriculture and the Undergraduate is a collection of essays and reports from discussion sessions that grew out of a 1991 conference. Neil Harl, the volume's reviewer, finds that the "volume is a potpourri of ideas on ways to improve undergraduate education. Some good. Some not so good. Some trivial. Some not so trivial. But all deserving of careful thought and further reflection." Given this, Harl masterfully shares with our readers his contemplations on education and agriculture and meeting the needs of agriculture in an ever-changing world. Harl finds that this volume makes a nice start in the direction of discussing undergraduate education involving physical and biological science in agriculture but neglects almost totally the social sciences. Is this an error of commission or omission?

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Evaluating Generic Dairy Advertising Impacts on Retail, Wholesale, and Farm Milk Markets

Harry M. Kaiser, Olan D. Forker, John Lenz, and Chin-Hwa Sun

Abstract. *This article develops a dynamic econometric model of the national dairy industry to simulate the impacts of generic advertising on the demand for milk and dairy products, farm and consumer prices, and producer welfare. Two advertising scenarios are analyzed: (1) a historic scenario, and (2) a pre-National Dairy Promotion and Research Board (NDPRB) scenario, where generic advertising expenditures are held constant at their quarterly levels during the year prior to the NDPRB's inception. The results indicate that the program has been effective in raising farm prices, increasing dairy product demand, and reducing cheese and butter purchases by the Government.*

Keywords. *Generic dairy advertising, dairy industry model, program impacts, dairy price support program.*

Since 1984, dairy farmers in the mainland United States have paid mandatory promotion assessments of 15 cents on every 100 pounds of milk marketed commercially to fund the National Dairy Promotion and Research Board (NDPRB). Legislative authority for these assessments, which exceed $200 million annually, is contained in the Dairy and Tobacco Adjustment Act of 1983. To increase milk and dairy product consumption, the NDPRB invests in generic dairy advertising and promotion, nutrition research, education, and new product development.

A substantial amount of research on the effectiveness of generic dairy advertising has been conducted within the past 20 years. A report prepared for the International Dairy Federation summarizes the results of 47 studies of generic dairy advertising programs (Forker and Kinnucan, 1991): 27 for fluid milk, 10 for butter, 5 for cheese, 3 for cream, and 1 for yogurt. All of the studies provided some measure of the market impact of generic advertising.

Methodology and estimation techniques have evolved to provide more reliable estimates of the economic relationship between sales or consumption and advertising expenditures, while controlling for other demand factors such as own-price, income level, price of substitutes, and demographics. Early studies with single-equation demand functions estimated for single products and limited market areas (Kinnucan and Fearon, 1986; Kinnucan and Forker, 1986; Thompson and Eiler, 1975) evolved into single-equation, single-product, multiple-market studies. Ward and Dixon (1989) combined data from 12 fluid milk markets for a pooled cross-section and time-series analysis. Liu and Forker (1990) developed single equations for three separate markets and used the equations to arrive at an optimal advertising allocation strategy among the three markets. In an earlier study, Liu and Forker (1988) incorporated a supply response function to account for any production response that might be generated by advertising-induced demand expansion. All of the fluid milk studies used aggregate market data to represent demand. In each of the fluid milk studies, models were specified as quantity-dependent, that is, advertising was assumed to directly influence the volume of sales but not price.

Other studies have estimated the impact of generic advertising of manufactured dairy products (cheese, butter, and cream) on demand (Blaylock and Blisard, 1990; Chang and Kinnucan, 1990; Kinnucan and Fearon, 1986; Liu and others, 1990; Strak and Gill, 1983; Yau, 1990). Two studies estimated a single demand equation for cheese that included a variable for generic cheese advertising expenditures (Blaylock and Blisard, 1990; Kinnucan and Fearon, 1986). A similar study was conducted for cream (Yau, 1990). Another study used multiple equations to account for the simultaneous impact of advertising on butter and other edible oils (Chang and Kinnucan, 1990). These studies have provided useful information to evaluate the performance of generic dairy advertising programs. Most studies, however, fail to simultaneously determine the impact of generic advertising on price and quantity.

Liu and others (1990, 1991) proposed a multiple-product, multiple-market level model that would simultaneously account for the direct demand impact and the cross-product impacts of concurrent advertising programs for several dairy products. The model concurrently takes into account the

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price and quantity impacts at three levels of trade—retail, wholesale, and farm. The study was one of the first to explicitly incorporate the government price support program into the manufactured product market.[1] Liu and others concluded that generic advertising has different effects on market variables depending on whether the market is competitive or in a government-support regime where market prices are below support prices.

This article extends the Liu analysis by developing a disaggregated industry model at the retail, wholesale, and farm levels with markets for fluid products, frozen products, cheese, and butter. A dynamic econometric model of the U.S. dairy industry is estimated using quarterly data from 1975 through 1990. The econometric results are then used to simulate the impacts of generic advertising on demand for milk and dairy products, farm and consumer prices, and producer welfare. Two advertising scenarios are analyzed: (1) a historic scenario in which generic advertising expenditures for fluid milk products, cheese, and butter are set equal to their actual levels for the simulation period, and (2) a pre-NDPRB scenario in which fluid product, cheese, and butter generic advertising expenditures are held constant at their quarterly levels during the year prior to the NDPRB inception. A comparison of the two scenarios provides insight into the national program's impacts on demand, supply, and prices at the retail, wholesale, and producer levels.

The Conceptual Model

The econometric model presented here is similar in structure to the Liu industry model, with two important differences. First, while the Liu model classified all manufactured products into one category (Class II), our model disaggregates manufactured products into three classes: frozen products, cheese, and butter. This disaggregation provides insight into the impacts of advertising on individual product demand. Second, instead of a raw milk supply function for the farm market, our model disaggregates farm milk supply into cow numbers and production per cow, which allows for more information on how the two components of milk supply are affected by generic advertising.

In the farm market of our model, Grade A (fluid eligible) milk is produced by farmers and sold to wholesalers. The wholesale market is disaggregated into four submarkets: fluid, frozen products, cheese, and butter.[2] It is assumed that the two major Federal programs that regulate the dairy industry (Federal milk marketing orders and the dairy price support program) are in effect. Since this is a national model, we assumed that there is one Federal milk marketing order regulating all milk marketed in the Nation. Under this program, fluid wholesalers pay the higher Class I price, while cheese wholesalers pay the lower Class III price.[3] The dairy price support program is incorporated into the model by constraining the wholesale cheese and butter prices to be greater than or equal to the government purchase prices. With the Federal Government offering to buy unlimited quantities of storable manufactured dairy products at announced prices, the program indirectly supports the farm milk price by increasing farm-level milk demand (fig. 1).

Retail markets are defined by sets of supply and demand functions and equilibrium conditions that require that supply equal demand. Since the market is disaggregated into fluid, frozen products, cheese, and butter, there are four sets of these equations, with each set having the following general specification:

$$Q^{rd} = f(P^r | S^{rd}), \tag{1.1}$$
$$Q^{rs} = f(P^r | S^{rs}), \tag{1.2}$$
$$Q^{rs} = Q^{rd} \equiv Q^r, \tag{1.3}$$

where Q^{rd} and Q^{rs} are retail demand and supply, P^r is the retail own-price, S^{rd} is a vector of retail demand shifters including generic and brand advertising, S^{rs} is a vector of retail supply shifters including the wholesale own-price, and Q^r is the equilibrium retail quantity.

The wholesale market is also defined by four sets of supply and demand functions and equilibrium conditions. The wholesale fluid and frozen product markets have the following general specification:

$$Q^{wd} = Q^r, \tag{2.1}$$
$$Q^{ws} = f(P^w | S^{ws}), \tag{2.2}$$
$$Q^{ws} = Q^{wd} \equiv Q^w \equiv Q^r, \tag{2.3}$$

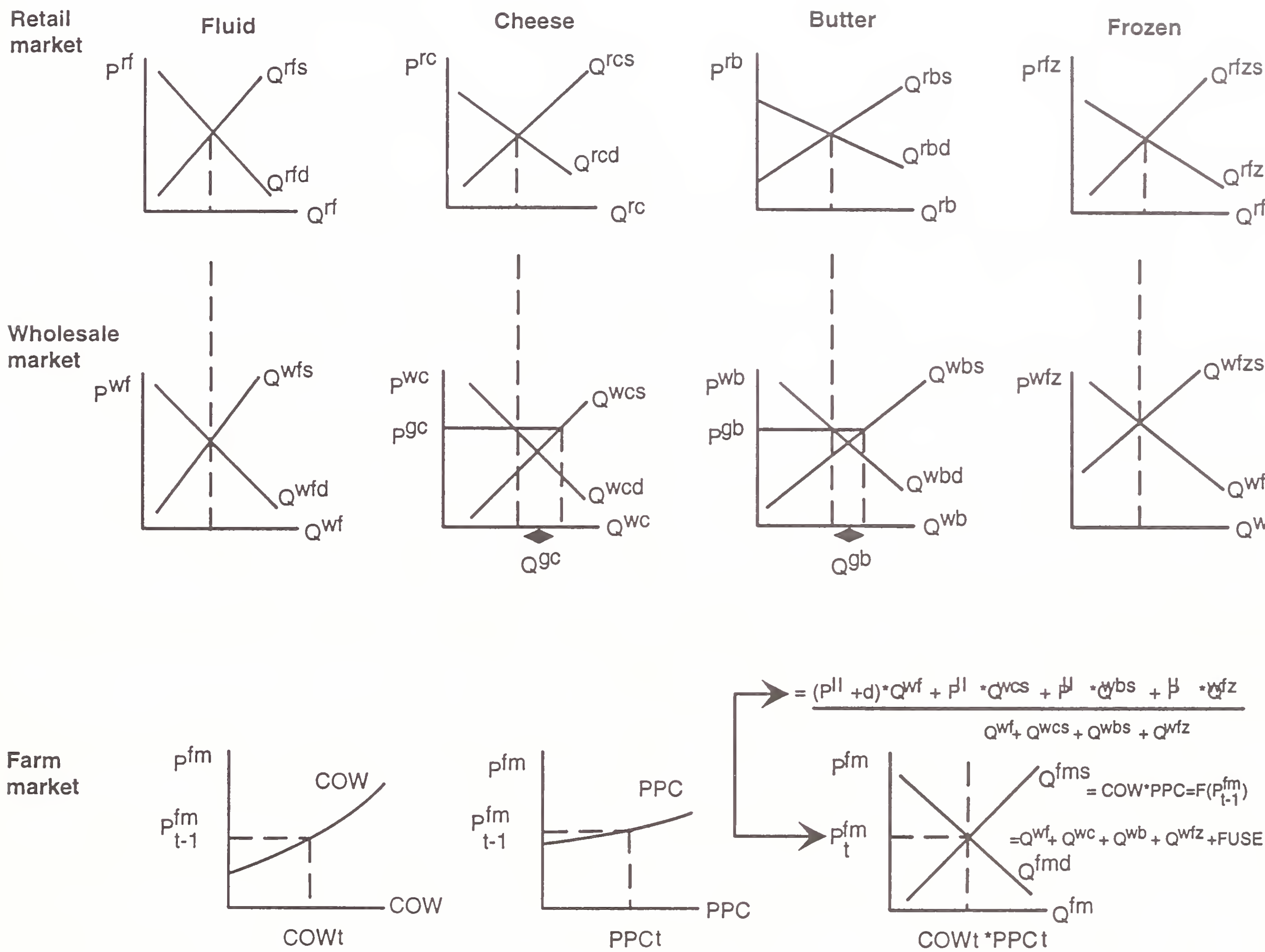
where Q^{wd} and Q^{ws} are wholesale demand and supply, P^w is the wholesale own-price, and S^{ws} is a

[1] A model by Thompson (1975) considered the effect of the dairy price support program on the farm milk price by including the support price as an explanatory variable in a farm price equation.

[2] All quantities in the model are expressed on a milkfat-equivalent basis. Consequently, nonfat dry milk is not considered in the model.

[3] Most Federal milk marketing orders utilize three product classes with Class I being fluid products, Class II being soft dairy products, and Class III being hard dairy products. A two-class system is used in this study, with all fluid products considered Class I and all manufactured products considered Class II.

Figure 1
Conceptual model of the dairy industry
(All quantities on a milkfat-equivalent basis)



vector of wholesale supply shifters. In the wholesale fluid supply equation, S^{ws} includes the Class I price, which equals the Class II milk price (that is, the Minnesota-Wisconsin price) plus a fixed fluid differential. In the frozen products, cheese, and butter wholesale supply functions, S^{ws} includes the Class II price, which is the most important variable cost to dairy processors. Wholesale-level demand functions do not have to be estimated since the equilibrium conditions constrain wholesale demand to be equal to the equilibrium retail quantity. The assumption that wholesale demand equals retail quantity implies a fixed-proportions production technology. Recent research by Wohlgenant and Haidacher (1989) suggests that this may not be a realistic assumption. However, the data used as a proxy for national demand are commercial disappearance statistics, which do not distinguish between wholesale and retail levels. Consequently, the assumption of fixed-proportions production technology is necessary.

Direct impacts of the dairy price support program occur in the wholesale cheese and butter markets. At this level, the Commodity Credit Corporation (CCC) provides an alternative source of demand at announced purchase prices. Consequently, the equilibrium conditions for the butter and cheese wholesale markets are different than those for the fluid and frozen wholesale markets:

$$Q^{wd} = Q^{r}, \quad (3.1)$$
$$Q^{ws} = f(P^{w} | S^{ws}), \quad (3.2)$$
$$Q^{ws} = Q^{wd} + \Delta INV + QSP \equiv Q^{w}, \quad (3.3)$$

where Q^{wd} and Q^{ws} are wholesale demand and supply, P^{w} is the wholesale own-price, S^{ws} is a vector of wholesale supply shifters including the Class II milk price, ΔINV is change in commercial inventories, QSP is quantity of product sold by specialty plants to the Government, and Q^{w} is the equilibrium wholesale quantity. The variables ΔINV and QSP represent a small proportion of

total milk production and are assumed to be exogenous in this model.[4]

The dairy price support program is incorporated in the model by constraining the wholesale cheese and butter prices to equal or exceed their government purchase prices:

$$P^{wc} \geqslant P^{gc}, \tag{4.1}$$
$$P^{wb} \geqslant P^{gb}, \tag{4.2}$$

where P^{gc} and P^{gb} are the government purchase prices for cheese and butter.

Because of the dairy price support program, four regimes are possible: (1) $P^{wc} > P^{gc}$ and $P^{wb} > P^{gb}$; (2) $P^{wc} > P^{gc}$ and $P^{wb} = P^{gb}$; (3) $P^{wc} = P^{gc}$ and $P^{wb} > P^{gb}$; or (4) $P^{wc} = P^{gc}$ and $P^{wb} = P^{gb}$. In the cheese and butter markets, specific versions of equilibrium condition 3.3 apply to the first regime, which is the competitive case. In the second case, where the cheese market is competitive but the butter market is not, the wholesale butter price is set equal to the government purchase price for butter and the equilibrium condition is changed to:

$$Q^{wbs} = Q^{wbd} + \Delta INV_b + QSP_b + Q^{gb} \equiv Q^{wb}, \tag{3.3b}$$

where Q^{gb} is government purchases of butter which becomes the new endogenous variable, replacing the wholesale butter price. For the third case, where the butter market is competitive but the cheese market is not, the wholesale cheese price is set equal to the government purchase price for cheese and the equilibrium condition is changed to:

$$Q^{wcs} = Q^{wcd} + \Delta INV_c + QSP_c + Q^{gc} \equiv Q^{wc}, \tag{3.3c}$$

where Q^{gc} is Government purchases of cheese which becomes the new endogenous variable, replacing the wholesale cheese price. For the last case, where both the cheese and butter markets are not competitive, the wholesale cheese and butter prices are set equal to their respective government purchase prices and the equilibrium conditions are changed to (3.3b) and (3.3c).[5]

The farm raw milk market is disaggregated into a national cow number equation, a national average-production-per-cow equation, and an identity that equates milk supply to the product of cow numbers and production per cow:

$$COW = f(E[P^{fm}] \| S^{cow}), \tag{5.1}$$
$$PPC = f(P^{fm} | S^{PPC}), \tag{5.2}$$
$$Q^{fm} = COW*PPC, \tag{5.3}$$

where COW is the number of dairy cows in the United States, $E[P^{fm}]$ is the expected farm milk price, S^{COW} is a vector of cow supply shifters, PPC is average production per cow, S^{PPC} is a vector of production-per-cow shifters, and Q^{fm} is farm milk supply. It is assumed that farmers have naive price expectations, that is, $E[P^{fm}]_t = P^{fm}_{t-1}$. Thus, the farm milk supply is predetermined and can be estimated using ordinary least squares. This assumption makes the simulation recursive, with the wholesale and retail markets forming a system, and the farm market independent from the system.

The farm milk price is a weighted average of the class prices for milk, with the weights equal to the utilization of milk among products:

$$P^{fm} = [(P^{II} + d) * Q^{wfs} + P^{II} * Q^{wfzs} + P^{II} * Q^{wcs} + P^{II} * Q^{wbs}]/[Q^{wfs} + Q^{wfzs} + Q^{wcs} + Q^{wbs}], \tag{5.4}$$

where: P^{II} is the Class II price, d is the Class I fixed fluid differential (therefore the Class I price is equal to P^{II} + d), Q^{wfs} is wholesale fluid supply, Q^{wfzs} is wholesale frozen product supply, Q^{wcs} is wholesale cheese supply, and Q^{wbs} is wholesale butter supply.

Finally, the model is closed by the following equilibrium condition:

$$Q^{fm} = Q^{wfs} + Q^{wfzs} + Q^{wcs} + Q^{wbs} + FUSE + OTHER, \tag{5.5}$$

where FUSE is onfarm use of milk and OTHER is milk used in dairy products other than fluid, frozen, butter, and cheese. Both of these variables

[4]Some cheese and butter plants sell products only to the Government regardless of the relationship between the wholesale market price and the purchase price. These balancing plants remove excess milk from the market when supply is greater than demand and process the milk into cheese and butter, which is then sold to the Government. Because of this, the quantity of milk purchased by the Government was disaggregated into purchases from these specialized plants and other purchases. In a competitive regime, the "other purchases" are expected to be zero, while the purchases from specialty plants may be positive. The QSP_c and QSP_b variables were derived by computing the average amount of government purchases of cheese and butter during competitive periods, that is, when the wholesale price was greater than the purchase price for these two products.

[5]Because the market structure is different under each of these four regimes, using conventional two-stage least squares to estimate the equations may result in selectivity bias. Theoretically, a switching simultaneous system regression procedure should be applied, which is described in Liu. However, this procedure is not used here because it is beyond the scope of this project. Applying this procedure to the level of disaggregation of this model's manufactured product market would have been extremely cumbersome, and the costs of doing so were judged to be greater than the potential benefits.

represent a small share of total milk production and are treated as exogenous.

Econometric Results

The farm market equations are estimated using ordinary least squares and quarterly data from 1970 through 1990. Retail and wholesale market equations are estimated simultaneously using two-stage least squares and quarterly data from 1975 through 1990. The retail-wholesale system has a shorter time series because advertising expenditures for the retail demand functions are not available prior to 1975. All equations are specified as a double-logarithm functional form. Estimation results are presented in table 1 with t-values given in parentheses under each coefficient. R^2 is the adjusted coefficient of determination and DW is the Durbin-Watson statistic. (See table 2 for definitions of variables in the econometric model.)

Table 1—Econometric results for the dairy industry model

Retail fluid demand:

$$\ln(Q^{rfd}/POP) = \underset{(-19.70)}{-\,2.380} - \underset{(-2.20)}{.036}\ln(P^{rf}/P^{bev}) + \underset{(6.56)}{.252}\ln(INC/CPI) - \underset{(-13.13)}{.067}\ln TREND$$

$$+ \underset{(10.60)}{.021}\,SIN1 + \underset{(15.90)}{.031}\,COS1 + \underset{(8.13)}{.005}\ln DGFAD + \underset{(8.13)}{.008}\ln DGFAD_{-1} + .009\ln DGFAD_{-2}$$

$$+ \underset{(8.13)}{.008}\ln DGFAD_{-3} + \underset{(8.13)}{.005}\ln DGFAD_{-4}$$

R^2 = .94; DW = 1.46

Retail frozen demand:

$$\ln(Q^{rfzd}/POP) = \underset{(-18.30)}{-\,4.433} - \underset{(-2.31)}{.364}\ln(P^{rfz}/P^{foo}) + \underset{(.24)}{.019}\ln(INC/CPI) - \underset{(-28.38)}{.146}\,SIN1$$

$$\underset{(-31.12)}{-\,.158}\,COS1 + \underset{(1.77)}{.0029}\ln(DBFZAD) + \underset{(1.77)}{.0046}\ln(DBFZAD)_{-1} + \underset{(1.77)}{.0052}\ln(DBFZAD)_{-2}$$

$$+ \underset{(1.77)}{.0046}\ln(DBFZAD)_{-3} + \underset{(1.77)}{.0029}\ln(DBFZAD)_{-4} + (1/(1 + \underset{(3.79)}{.458}\,L))\,U^{rfzd}$$

R^2 = .96; DW = 1.52

Retail cheese demand:

$$\ln(Q^{rcd}/POP) = \underset{(-5.29)}{-\,2.609} - \underset{(-.93)}{.200}\ln(P^{rc}/P^{mea}) + \underset{(2.68)}{.591}\ln(INC/CPI) + \underset{(1.06)}{.039}\ln TREND$$

$$+ \underset{(4.93)}{.290}\,DUM_{82.2} - \underset{(-7.07)}{.434}\,DUM_{83.1} + \underset{(.26)}{.0004}\ln DGCAD + \underset{(.26)}{.0007}\ln DGCAD_{-1} + \underset{(.26)}{.0008}\ln DGCAD_{-2}$$

$$+ \underset{(.26)}{.0007}\ln DGCAD_{-3} + \underset{(.26)}{.0004}\ln DGCAD_{-4} + \underset{(1.05)}{.007}\ln DBCAD + \underset{(1.05)}{.012}\ln DBCAD_{-1}$$

$$+ \underset{(1.05)}{.013}\ln DBCAD_{-2} + \underset{(1.05)}{.012}\ln DBCAD_{-3} + \underset{(1.05)}{.007}\ln DBCAD_{-4} + (1/(1 + \underset{(1.07)}{.158}\,L))\,U^{rcd}$$

R^2 = .77; DW = 1.74

Retail butter demand:

$$\ln(Q^{rbd}/POP) = \underset{(-11.78)}{-\,3.640} - \underset{(-.66)}{.077}\ln(P^{rb}/INC) + \underset{(4.44)}{.082}\,COS1 + \underset{(2.70)}{.034}\,COS2$$

continued ...

Table 1—Econometric results for the dairy industry model—continued

$$+ \underset{(1.09)}{.0016} \ln (DGBAD) + \underset{(.50)}{.008} \ln (DBBAD) - \underset{(-2.41)}{.044} \ln TREND - \underset{(-3.61)}{.361} DUM_{80.2} - \underset{(-3.88)}{.392} DUM_{89.2}$$

$R^2 = .55$; $DW = 1.93$

Retail fluid supply:

$$\ln Q^{rfs} = \underset{(4.16)}{1.266} + \underset{(3.45)}{.793} \ln (P^{rf}/P^{wf}) - \underset{(-4.21)}{.057} \ln (P^{fe}/P^{wf}) + \underset{(5.06)}{.0284} \ln TREND + \underset{(2.37)}{.009} SIN1$$

$$+ \underset{(6.62)}{.0385} COS1 + \underset{(3.15)}{.392} \ln (Q^{rfs})_{-1} + \underset{(.58)}{.070} \ln (Q^{rfs})_{-4}$$

$R^2 = .96$; $DW = 1.93$

Retail frozen product supply:

$$\ln Q^{rfzs} = \underset{(77.03)}{1.100} + \underset{(1.14)}{.323} \ln (P^{rfz}/P^{wfz}) - \underset{(-1.23)}{.056} \ln (P^{fe}/P^{wfz}) - \underset{(-13.43)}{.149} SIN1 - \underset{(-13.97)}{.155} COS1$$

$$+ \underset{(2.12)}{.289} (U^{rfzs})_{-1}$$

$R^2 = .87$; $DW = 1.59$

Retail cheese supply:

$$\ln Q^{rcs} = \underset{(-1.09)}{-.640} + \underset{(1.41)}{.322} \ln (P^{rc}/P^{wc}) - \underset{(-.48)}{.086} \ln (P^{lab}/P^{wc}) + \underset{(1.10)}{.012} SIN1 + \underset{(.93)}{.010} COS1$$

$$+ \underset{(3.57)}{.258} \ln (Q^{rcs})_{-1} + \underset{(7.15)}{.473} \ln (Q^{rcs})_{-4} + \underset{(5.47)}{.306} DUM_{82.2} - \underset{(-8.08)}{.460} DUM_{83.1}$$

$R^2 = .87$; $DW = 2.12$

Retail butter supply:

$$\ln Q^{rbs} = \underset{(-1.20)}{-2.998} + \underset{(1.51)}{1.255} \ln (P^{rb}/P^{wb}) - \underset{(-1.13)}{.558} \ln (P^{lab}/P^{wb}) - \underset{(-1.00)}{.079} \ln (P^{fe}/P^{wb})$$

$$+ \underset{(2.47)}{.052} COS1 + \underset{(2.76)}{.033} COS2 + \underset{(3.20)}{.332} \ln (Q^{rbs})_{-1} - \underset{(-3.95)}{.371} DUM_{80.2} - \underset{(-4.14)}{.389} DUM_{89.2}$$

$R^2 = .64$; $DW = 1.88$

Wholesale fluid supply:

$$\ln Q^{wfs} = \underset{(2.13)}{.283} + \underset{(4.29)}{.157} \ln (P^{wf}/(P^{II}+d)) - \underset{(-1.40)}{.014} \ln (P^{fe}/(P^{II}+d)) - \underset{(-.31)}{.001} \ln TREND$$

$$+ \underset{(7.28)}{.038} COS1 + \underset{(2.28)}{.003} COS2 + \underset{(6.17)}{.580} \ln (Q^{wfs})_{-1} + \underset{(1.97)}{.201} \ln (Q^{wfs})_{-4}$$

$R^2 = .96$; $DW = 2.35$

Wholesale frozen supply:

$$\ln Q^{wfzs} = \underset{(2.90)}{.278} + \underset{(.72)}{.053} \ln (P^{wfz}/P^{II}) - \underset{(-2.84)}{060} SIN1 - \underset{(-5.18)}{.158} COS1 - \underset{(-4.31)}{.024} COS2$$

$$+ \underset{(2.30)}{.291} \ln (Q^{wfzs})_{-1} + \underset{(1.46)}{.267} \ln (Q^{wfzs})_{-4} + \underset{(2.99)}{.032} \ln TREND$$

continued ...

Table 1—Econometric results for the dairy industry model—continued

R^2 = .97; DW = 2.23

Wholesale cheese supply:

$$\ln Q^{wcs} = \underset{(.49)}{.362} + \underset{(.36)}{.126} \ln (P^{wc}/P^{II}) + \underset{(4.68)}{.042} \text{ SIN1} - \underset{(-5.21)}{.037} \text{ COS1} + \underset{(5.59)}{.030} \text{ COS2} + \underset{(7.71)}{.661} \ln (Q^{wcs})_{-1}$$

$$+ \underset{(3.85)}{.313} \ln (Q^{wcs})_{-4} - \underset{(-1.78)}{.026} \text{ DTP} - \underset{(-3.72)}{.060} \text{ MDP}$$

R^2 = .95; DW = 1.41

Wholesale butter supply:

$$\ln Q^{wbs} = \underset{(3.11)}{1.211} + \underset{(1.65)}{.207} \ln (P^{wb}/P^{II}) + \underset{(15.19)}{.222} \text{ SIN1} + \underset{(1.39)}{.037} \text{ COS1} + \underset{(4.23)}{.509} \ln (Q^{wbs})_{-1}$$

$$+ \underset{(3.42)}{.004} \text{ TREND} - \underset{(-1.96)}{.075} \text{ DTP} - \underset{(-1.471)}{.052} \text{ MDP}$$

R^2 = .86; DW = 1.99

Cow numbers:

$$\ln COW = \underset{(2.64)}{.244} + \underset{(13.73)}{1.600} \ln COW_{-1} - \underset{(-4.91)}{.929} \ln COW_{-2} + \underset{(3.08)}{.306} \ln COW_{-3} + \underset{(1.81)}{.012} \ln (P^{fm}/P^{feed})_{-1}$$

$$- \underset{(-1.27)}{.004} \ln (P^{COW}/P^{fr}) - \underset{(-4.33)}{.009} \text{ DTP}$$

R^2 = .99; DW = 1.91

Production per cow:

$$\ln PPC = \underset{(5.80)}{4.652} + \underset{(4.01)}{.412} \ln PPC_{-1} + \underset{(1.34)}{.031} \ln (P^{fm}/P^{feed}) + \underset{(5.68)}{.003} \text{ FTREND} + \underset{(2.80)}{.019} \text{ SIN1}$$

$$- \underset{(-20.23)}{.062} \text{ COS1} + \underset{(4.97)}{.011} \text{ COS2} - \underset{(-2.34)}{.020} \text{ MDP}$$

R^2 = .98; DW = 1.77

Table 2—Variable definitions for the econometric model

Endogenous variables:

Q^{rfd} = retail fluid demand measured in bil. lbs. of milkfat equivalent.
P^{rf} = consumer retail price index for fresh milk and cream (1982-84 = 100).
Q^{rfzd} = retail frozen dairy product demand measured in bil. lbs. of milkfat equivalent.
P^{rfz} = consumer retail price index for frozen dairy products (1982-84 = 100).
Q^{rcd} = retail cheese demand measured in bil. lbs. of milkfat equivalent.
P^{rc} = consumer retail price index for cheese (1982-84 = 100).

Table 2—Variable definitions for the econometric model—continued

Q^{rbd} = retail butter demand measured in bil. lbs. of milkfat equivalent.
P^{rb} = consumer retail price index for butter (1982-84 = 100).
Q^{rfs} = retail fluid supply measured in bil. lbs. of milkfat equivalent. ($Q^{rfs} = Q^{rfd}$).
P^{wf} = wholesale fluid price index (1982 = 100).
Q^{rfzs} = retail frozen dairy product supply measured in bil. lbs. of milkfat equivalent. ($Q^{rfzs} = Q^{rfzd}$).
P^{wfz} = wholesale frozen dairy products price index (1982 = 100).
Q^{rcs} = retail cheese supply measured in bil. lbs. of milkfat equivalent. ($Q^{rcs} = Q^{rcd}$).

Table 2—Variable definitions for the econometric model—continued

P^{wc} = wholesale cheese price measured in cents/lb.,
Q^{rbs} = retail butter supply measured in bil. lbs. of milkfat equivalent, ($Q^{rbs} = Q^{rbd}$),
P^{wb} = wholesale butter price measured in cents/lb.,
Q^{wfs} = wholesale fluid supply measured in bil. lbs. of milkfat equivalent, ($Q^{wfs} = Q^{rfs} = Q^{rfd}$),
P^{II} = Class II price for raw milk measured in dollars/cwt.,
Q^{wfzs} = wholesale frozen dairy product supply measured in bil. lbs. of milkfat equivalent, ($Q^{wfzs} = Q^{rfzs} = Q^{rfzd}$),
Q^{wcs} = wholesale cheese supply measured in bil. lbs. of milkfat equivalent, ($Q^{wcs} = Q^{rcs} = Q^{rcd}$),
COW = U.S. cow numbers measured in thousands,
P^{fm} = U.S. average all milk price measured in dollars/cwt.,
PPC = U.S. average milk production-per-cow measured in lbs.,

Exogenous variables and other definitions:

POP = U.S. population measured in millions,
P^{bev} = consumer retail price index for nonalcoholic beverages (1982-84 = 100),
INC = disposable personal income per capita, measured in thousand dollars,
CPI = consumer price index for all items (1982-84 = 100),
TREND = time trend variable for the retail and wholesale-level equations, equal to 1 for 1975, quarter 1,...,
SIN1 = harmonic seasonal variable representing the first wave of the sine function,
COS1 = harmonic seasonal variable representing the first wave of the cosine function,
DGFAD = generic fluid advertising expenditures deflated by the media price index, measured in thousand dollars,
P^{foo} = consumer retail price index for food (1982-84 = 100),
DBFZAD = brand frozen product advertising expenditures deflated by the media price index, measured in thousand dollars,
L = lag operator,
U^{rfzd} = error term for retail frozen demand,
P^{mea} = consumer retail price index for meat (1982-84 = 100),
$DUM_{82.2}$ = intercept dummy variable equal to 1 for 1982, quarter 2, equal to 0 otherwise,
$DUM_{83.1}$ = intercept dummy variable equal to 1 for 1983, quarter 1, equal to 0 otherwise,
DGCAD = generic cheese advertising expenditures deflated by the media price index, measured in thousand dollars
DBCAD = brand cheese advertising expenditures deflated by the media price index, measured in thousand dollars,
u^{rcd} = error term for retail cheese demand,
COS2 = harmonic seasonal variable representing the second wave of the cosine function,
$DUM_{80.2}$ = intercept dummy variable equal to 1 for 1980, quarter 2, equal to 0 otherwise,
$DUM_{89.2}$ = intercept dummy variable equal to 1 for 1989, quarter 2, equal to 0 otherwise,
DGBAD = generic butter advertising expenditures deflated by the media price index, measured in thousand dollars,
DBBAD = brand butter advertising expenditures deflated by the media price index, measured in thousand dollars,
P^{fe} = producer price index for fuel and energy (1967 = 100),
U^{rfzs} = error term for retail frozen supply,
P^{lab} = average hourly wage in food manufacturing sector (dollars/hour),
d = Class I fixed price differential for raw milk measured in dollars/cwt.,
DTP = intercept dummy variable for the Dairy Termination Program equal to 1 for 1986, quarter 2 through 1987, quarter 3; equal to 0 otherwise,
MDP = intercept dummy variable for the Milk Diversion Program equal to 1 for 1984, quarter 1 through 1985, quarter 2; equal to 0 otherwise,
Q^{wbs} = wholesale butter supply measured in bil. lbs. of milkfat equivalent, ($Q^{wbs} = Q^{rbs} = Q^{rbd}$),
P^{feed} = U.S. average price per ton of 16 percent protein dairy feed,
P^{fr} = U.S. index of prices received by farmers,
P^{COW} = U.S. average slaughter cow price measured in dollars/cwt.,
FTREND = time trend variable for the farm-level equations, equal to 1 for 1970, quarter 1,...,

Retail market demand functions are estimated on a per capita basis. Retail demand for each product is specified to be a function of the retail product price, the price of substitutes, per capita disposable income deflated by the Consumer Price Index, seasonal harmonic variables to account for seasonal demand, a time trend variable to capture changes in consumer tastes and preferences over time, and generic and brand advertising expenditures. In all demand functions except butter, own-prices are deflated by the price of substitute products. For the butter demand function, the own-price is deflated by per capita income since the substitute price approach yields inferior statistical results. Based on the autocorrelation and partial autocorrelation functions, a first-order autoregressive error structure is imposed for the retail frozen demand function.

The generic and brand advertising variables are specified two ways for each equation, with the

form that resulted in the best statistical fit being used. The first approach specifies advertising expenditures as a second-order polynomial distributed lag with both endpoint restrictions imposed. The second method simply uses current advertising expenditures as the explanatory variable. For the retail fluid demand function, generic advertising is specified as a second-order polynomial distributed lag with both endpoint restrictions imposed, while brand advertising is omitted because the estimated coefficient is negative and insignificant. In the retail frozen products demand function, a second-order polynomial distributed lag model with both endpoint restrictions imposed is used for brand advertising. Generic advertising expenditures for frozen products are omitted because they are negative and not statistically significant. In the retail cheese demand function, a second-order polynomial distributed lag model with both endpoint restrictions imposed is used for both generic and brand advertising. Two intercept dummy variables, to capture outliers for quarter 2 of 1982 and quarter 1 of 1983, are also included in the retail cheese demand function. Retail cheese demand for these two quarters was well out of the range of all other observations. Current generic and brand advertising expenditures in the retail butter demand equation yield a better statistical fit than the model with lag structures. In addition, two intercept dummy variables are included in the retail butter demand function to account for two outliers, quarter 2 of 1980 and quarter 2 of 1989.

Based on the estimation, brand cheese and generic fluid advertising have the largest coefficients of all advertising.[6] The sum of the current and lagged coefficients for brand cheese advertising is 0.05, while the sum of the current and lagged coefficients on generic fluid advertising is 0.035. Frozen product advertising coefficients sum to 0.02. Both generic cheese and brand butter advertising are statistically insignificant, and generic butter advertising has a relatively small sum of 0.0016.

The retail supply for each product is estimated as a function of the retail price; the wholesale price, which represents the major variable cost to retailers; the producer price index for fuel and energy; the average hourly wage in the food manufacturing sector; a time trend variable; seasonal harmonic variables; and lagged retail supply. The producer price index for fuel and energy is a proxy for variable energy costs, while the average hourly wage captures labor costs in the retail supply functions. The seasonal harmonic variables capture seasonality in retail supply, while the lagged supply variables represent capacity constraints. The time trend variable is a proxy for technological change in retailing. Not all of these variables remain in each of the final estimated retail supply equations. In addition, intercept dummy variables appear in the cheese and butter retail supply equations to account for outliers in these two markets. Finally, a first-order moving average error structure is imposed on the retail frozen product supply equation.

The wholesale supply for each product is estimated as a function of the wholesale price: the appropriate Class price for milk (Class II or Class I = Class II + d), which represents the main variable cost to wholesalers; the producer price index for fuel and energy; a time trend variable; seasonal harmonic variables; and lagged wholesale supply. The producer price index for fuel and energy is included because energy costs are important variable costs to wholesalers, and the seasonal harmonic variables capture seasonality in wholesale supply. Lagged wholesale supply reflects capacity constraints, and the trend variable is a measure of technological change in dairy product processing.

For the farm milk market, the cow number equation is estimated as a function of the number of cows in previous periods, a one-period lagged ratio of the farm milk price to the price of 16 percent protein feed, the ratio of the price of slaughter cows to the index of prices received by farmers, and an intercept dummy variable to account for the quarters when the 1986-87 Dairy Termination Program was in effect. Lagged cow numbers are included as biological capacity constraints to current cow numbers, while the feed price represents one of the most important variable costs in milk production. The price of slaughter cows deflated by the index of prices received is included because it represents an opportunity cost of retaining cows.

The production-per-cow equation is estimated as a function of production per cow in the previous period, the ratio of the farm milk price to the price of 16-percent protein feed, a time trend variable, seasonal harmonic variables to account for seasonality in production per cow, and an intercept dummy variable to account for the quarters when the 1984-85 Milk Division Program was in effect. Lagged production per cow is included as a capacity constraint, the feed price is included because it represents one of the most important variable costs, and the time trend is included to capture genetic improvements over time. Note that the milk-feed price ratio is not lagged in the production-per-cow equation because some changes in production per cow can be made instantaneously, while changes in cow numbers cannot.

[6] These coefficients are partial advertising elasticities from the structural retail demand equations. They are not the total elasticities from the reduced-form price equations.

In terms of statistical fit, most of the estimated equations are reasonable with respect to R^2, and all signs are as expected. In all but two equations, the adjusted coefficient of determination is above 0.77, and all but three are above 0.86. The two equations that are the most difficult to estimate are the retail butter demand and supply equations. The retail butter demand equation has the lowest R^2 (0.55), and the retail butter supply equation has an R^2 of 0.64. On the whole, the equations are deemed reasonable for the simulation model.

Validation of the Simulation Model

To validate the model, a dynamic in-sample simulation is performed from the third quarter of 1984 (1984.3) through the fourth quarter of 1990 (1990.4), the period in which the NDPRB has been in operation. Results should be judged in terms of how close the predicted endogenous variables are to their historic values. The dynamic simulation is conducted as follows. First, all exogenous variables are set equal to their historic levels for the simulation period. Second, all lagged dependent variables and the predetermined farm milk supply for the first simulation period (1983.4) are set equal to their actual levels for the previous period (1983.2) and the retail-wholesale system of equations (product-specific versions of equations 1.1-4.2, as well as 5.5) is solved simultaneously using the Newton method. Third, predicted values for wholesale quantities and the Class II price are substituted into the farm milk price equation (equation 5.4) to obtain the farm price. Fourth, the current-period predicted farm milk price is substituted into the cow number and production-per-cow equations to obtain the farm milk supply for the subsequent period. Finally, the predicted endogenous variables become the lagged endogenous variables for the subsequent period, and the predetermined farm milk supply becomes the milk supply for the second period of the simulation. This process is repeated until the last period of the simulation (1990.4) is reached.

To measure how close each predicted endogenous variable is to its historic level, the root-mean-square-percent-simulation error (RMSPSE) measure is computed, which is equal to the following formula:

$$\text{RMSPSE} = \{(1/N) \sum_{t=1}^{N} ((YS_t - YA_t)/YA_t))^2\}^{1/2},$$

where YS_t is the simulated value of endogenous variable Y, YA_t is the actual historic value for endogenous variable Y, and N is the number of periods in the simulation.

Table 3 shows the RMSPSE for all endogenous variables in the model. Generally, the RMSPSE's

Table 3—Quarterly average of the historic and predicted endogenous variables from the dynamic simulation and root-mean-square-percent-simulation error (RMSPSE)

Endogenous variable	Unit	Historic average	Simulation average	RMSPE
				Percent
Q^{rf}	bil. lbs.	13.41	13.43	0.9
Q^{rfz}	bil. lbs.	3.31	3.26	3.0
Q^{rcd}	bil. lbs.	9.43	9.56	4.7
Q^{wcs}	bil. lbs.	9.92	9.77	4.2
Q^{rbd}	bil. lbs.	4.93	3.40	30.9
Q^{wbs}	bil. lbs.	6.57	6.75	7.1
P^{rf}	1982-84 = 100	108.6	107.1	15.1
P^{rfz}	1982-84 = 100	117.5	122.4	6.8
P^{rc}	1982-84 = 100	111.1	105.2	8.4
P^{rb}	1982-84 = 100	101.8	84.5	17.2
P^{wf}	1982 = 100	108.5	106.8	16.3
P^{wfz}	1982 = 100	112.0	104.1	14.2
P^{wc}	$/lb.	1.30	1.21	11.2
P^{wb}	$/lb.	.33	1.31	3.5
P^{II}	$/cwt.	11.67	11.61	22.9
Q^{fs}	bil lbs.	35.84	38.40	9.1
P^{fm}	$/cwt.	12.85	12.61	21.2
CCC	bil. lbs.	2.15	3.57	201.7
COW	1,000 head	10472	11361	10.4
PPC	number	3428	3377	2.9

for the supply and demand quantities are quite reasonable. With the exception of retail butter demand, all retail, wholesale, and farm supply and demand quantities have RMSPSE's under 10 percent. However, retail butter demand has an RMSPSE of 30.9 percent. Recall that the retail butter market equation had the poorest statistical fit of all equations in the model. Consequently, it is not surprising that retail butter demand has a high RMSPSE. With respect to prices, the RMSPSE's tend to be higher, ranging from 3.5 percent for the wholesale butter price to 24.5 percent for the Class II price. Several outliers in the dynamic simulation cause these relatively high RMSPSE's. Except for these outliers, the simulated prices track the actual prices better than the RMSPSE's indicate. Finally, the high RMSPSE for CCC purchases is due to the small magnitude of this variable, that is, a small deviation from the actual value leads to a large RMSPSE.

Analysis of Advertising Scenarios

To evaluate the impacts of the generic dairy promotion program on the retail, wholesale, and farm markets, the historic simulation is compared with a pre-NDPRB scenario. In the historical simulation scenario, generic advertising levels are set equal to their real (inflation-adjusted) values for 1984.3 through 1990.4.[7] In the pre-NDPRB scenario, generic advertising levels are set equal to their real values in the year preceding the enactment of the national program. That is, quarterly generic fluid, cheese, and butter advertising expenditures for the entire simulation period are held constant at their quarterly real levels in the third and fourth quarters of 1983 and the first and second quarters of 1984. A comparison of the two scenarios indicates the NDPRB's impact on dairy markets. Generic frozen product advertising is not included in the retail frozen product demand function. Consequently, generic advertising expenditure levels for frozen products are not included in the advertising scenarios.

Figures 2-4 present generic advertising expenditure levels for the two scenarios for fluid, cheese, and butter. Historic generic fluid advertising expenditures tend to be about twice as large as those in the pre-NDPRB scenario (fig. 2), especially from 1986 on. In the early periods of the simulation, generic cheese advertising expenditures are higher for the historic than the pre-NDPRB scenario (fig. 3). However, from mid-1987 through 1990, generic cheese advertising expenditure levels are similar between scenarios. On the other hand, generic butter advertising is vastly different between the two scenarios (fig. 4). There was no generic advertising for butter prior to 1984.3. Consequently, generic butter advertising is set equal to zero for the pre-NDPRB scenario, while the historic scenario generally has positive levels of generic butter expenditures throughout the simulation period.[8]

Results of the two simulations show that the doubling of generic fluid advertising due to the national program results in a 2-percent increase in fluid demand. The increase in fluid demand causes the retail fluid price to increase by 6 percent. The increase in fluid demand also causes the wholesale fluid price to increase by 5 percent (table 4).

Frozen product demand, which does not contain generic frozen product advertising as a demand shifter, declines slightly (0.31 percent) with the national program since total milk demand increases by 1 percent under the national program, causing farm and wholesale-level prices for all products to rise. The average increase in the wholesale frozen price is 1 percent which results in the retail frozen price rising an average of 0.4 percent.

The modest increase in cheese demand (0.1 percent) under the national program is due to several factors. First, generic cheese advertising expenditures are only slightly higher under the national program. Second, the elasticity of demand with respect to generic advertising is very low. Finally, there is a slight average increase in the retail cheese price of 0.1 percent. Wholesale cheese supply decreases by 2.05 percent under the national program due to the Class II price increase of 2.33 percent. The Class II price is the most important wholesale cheese supply shifter. The leftward shift in wholesale cheese supply, however, is not enough to cause the wholesale cheese price to increase because even after the shift, the Government still purchases excess cheese supply. Hence, the wholesale cheese price is the same as the purchase price for cheese in both advertising scenarios. The national program results in an average decrease of 0.21 billion pounds (per quarter) of cheese purchased by the Government due to a slight increase in commercial cheese

[7]All advertising expenditures (generic and brand) come from various issues of Leading National Advertisers. Due to their survey procedures, these expenditures are regarded as being lower than actual expenditures. However, alternative data sources for brand and generic advertising expenditures are not available. As is pointed out by Maddala (1977, pp. 292-94), this creates an error in variable problem that may bias the estimated advertising coefficients downward (as opposed to upward bias, as one might intuitively expect). Consequently, some care should be exercised in interpreting these coefficients.

[8]Actually, generic butter advertising expenditures were set to one dollar rather than zero since this is a double logarithm model.

Figure 2
Generic fluid milk advertising expenditures, historic and pre-NDPRB scenarios

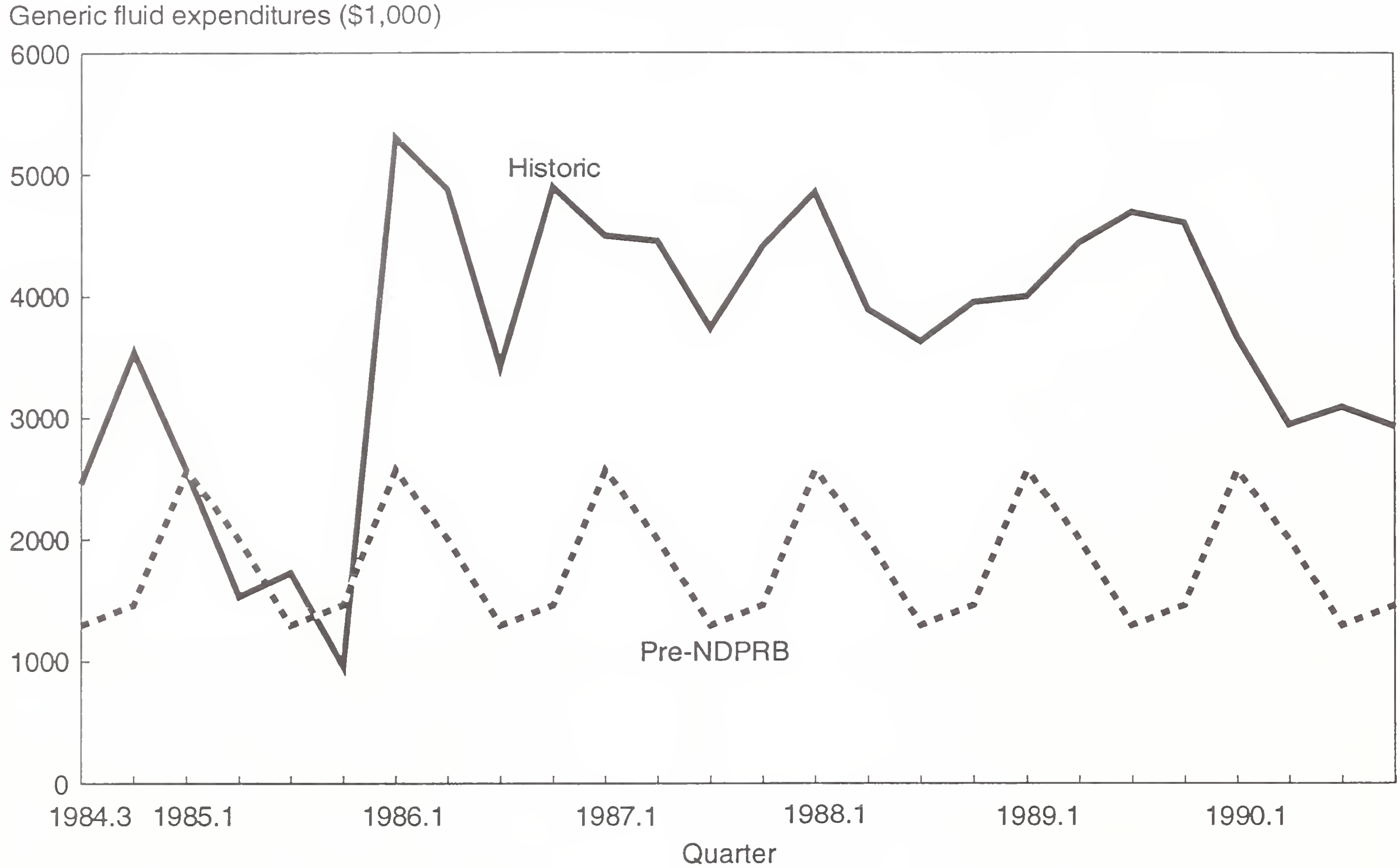


Figure 3
Generic cheese advertising expenditures, historic and pre-NDPRB scenarios

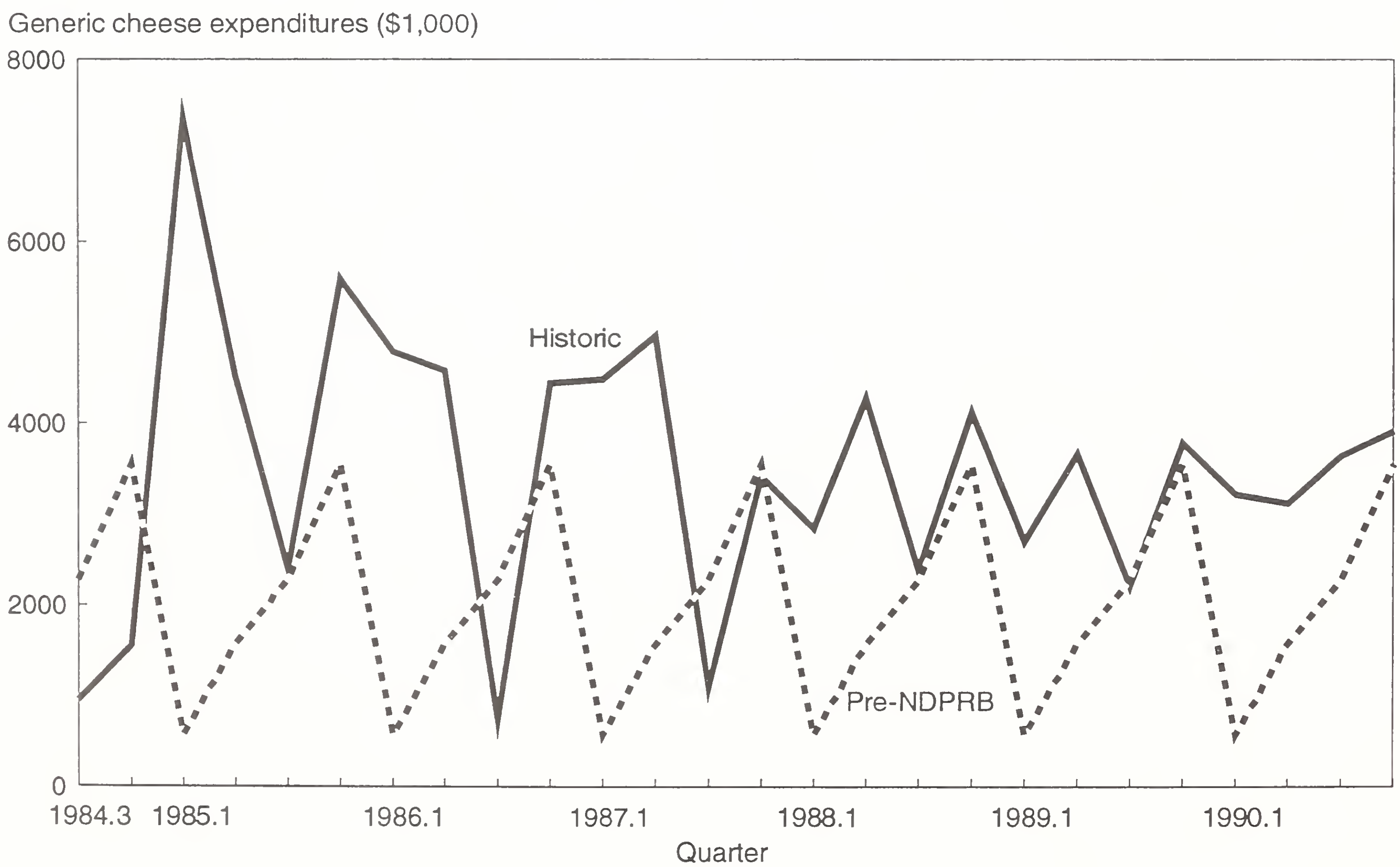


Figure 4
Generic butter advertising expenditures, historic and pre-NDPRB scenarios

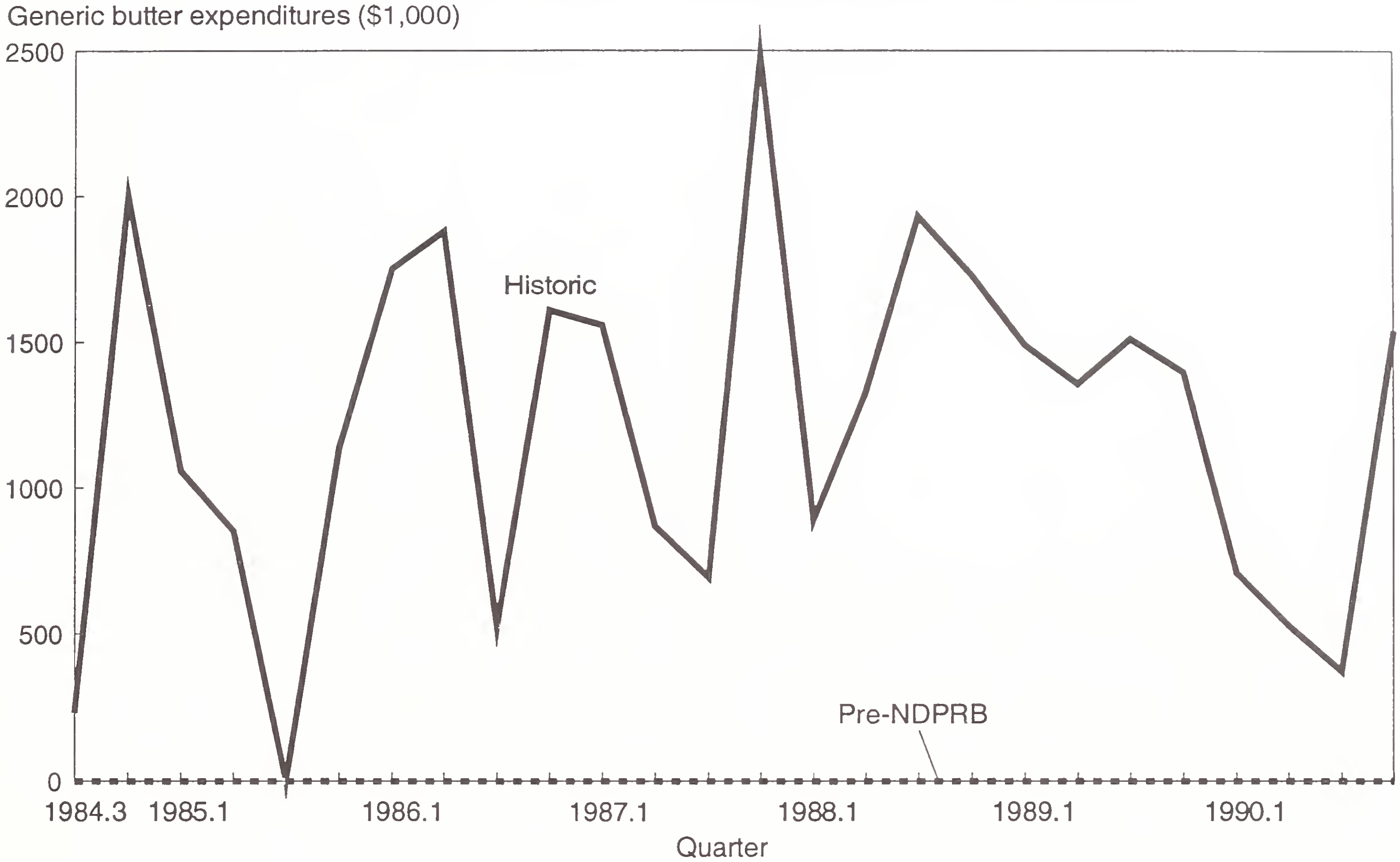


Table 4—Quarterly average of endogenous variables for the two advertising scenarios, 1984.3-1990.4

Endogenous variable	Unit	Historic simulation average	Pre-NDPRB simulation average	Percent change
				Percent
Q^{rf}	bil. lbs.	13.43	13.16	2.00
Q^{rfz}	bil. lbs.	3.26	3.27	0.31
Q^{rcd}	bil. lbs.	9.56	9.55	0.10
Q^{wcs}	bil. lbs.	9.77	9.97	–2.05
Q^{rbd}	bil. lbs.	3.40	3.37	0.90
Q^{wbs}	bil. lbs.	6.75	6.81	–0.89
P^{rf}	1982-84 = 100	107.1	100.6	6.07
P^{rfz}	1982-84 = 100	122.4	121.9	0.41
P^{rc}	1982-84 = 100	105.2	105.1	0.10
P^{rb}	1982-84 = 100	84.5	84.0	0.60
P^{wf}	1982 = 100	106.8	101.5	4.96
P^{wfz}	1982 = 100	104.1	103.1	0.96
P^{wc}	$/lb.	1.21	1.21	0.00
P^{wb}	$/lb.	1.31	1.31	0.00
P^{II}	$/cwt.	11.61	11.34	2.33
Q^{fs}	bil. lbs.	38.40	38.19	0.55
P^{fm}	$/cwt.	12.61	12.33	2.22
Q^{gc}	bil. lbs.	0.23	0.44	–91.3
Q^{gb}	bil lbs.	3.34	3.44	–2.99
CCC	bil. lbs.	3.57	3.88	–8.70
COW	1,000 head	11361	11315	0.40
PPC	number	3377	3373	0.12

demand and the 2.05-percent decrease in wholesale supply of cheese.

Butter demand increases by 0.9 percent under the national program due to higher generic butter advertising expenditures (generic butter advertising was zero prior to the national program). The increased demand causes an increase of 0.6 percent in the retail butter price. There is no rise in the wholesale butter price, which is equal to the government purchase price under both advertising scenarios. While butter demand increases, wholesale butter supply actually decreases by 0.9 percent under the national program. As for cheese, the decrease in wholesale butter supply is the result of the Class II price increasing by 2.33 percent. The modest increase in butter demand and decrease in wholesale butter supply cause butter purchases by the Government to fall by 0.1 billion pounds (per quarter) under the national program.

The introduction of the NDPRB also has an impact on the farm market. The Class II and farm milk prices increase by 2.33 percent and 2.22 percent under the national program due to an increase of 1 percent in milk demand. Farm supply, in turn, rises by about 0.45 percent in cow numbers and 0.1 percent increase in production per cow.

Conclusions

Econometric results indicate that the national generic dairy promotion program has affected the retail, wholesale, and farm markets for dairy products. At the retail level, the demand for fluid milk and butter increased modestly due to this program. The demand for cheese also increased due to the national program, but the increase was marginal. On the other hand, the demand for frozen products decreased slightly due to price increases that outweighed advertising effects. The overall effect of the program was to increase total demand for milk by 1 percent. All retail and wholesale prices were higher due to the national program. The national program also was effective in raising both farm prices and farm milk supply. The program resulted in a farm milk price that was 2.22 percent higher than in the absence of the national program. Hence, it appears that the program has been an effective means to both raise farm prices and modestly increase the demand for milk and dairy products, as well as to reduce cheese and butter purchases by the Government.

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Development and Measurement of Farm-to-Retail Price Linkage for Evaluating Dairy Advertising Effectiveness

Michael K. Wohlgenant and Cynda R. Clary

Abstract. *A conceptual and empirical framework for estimating the effects of dairy advertising on farm prices and producer returns is developed. The model consists of an industry-derived demand equation for milk linking advertising and government purchases to farm price, and a government purchases equation linking advertising and support prices to government purchases. The econometric model is a mixed continuous/discrete system, estimated by the Amenyia Principle. The two-equation system is estimated for both aggregated manufactured advertising and disaggregated manufactured advertising. The results are consistent with theory and show significant effects of advertising, particularly for fluid advertising.*

Keywords. *Dairy advertising, demand, government purchases, price linkage, Tobit.*

Retail-to-farm demand linkage of advertising is affected by dairy policy at the manufacturing and farm levels, as are the physical and economic relationships between retail products and the raw farm product. While previous studies have focused on the impact of dairy product advertising expenditures on consumer demand for the products, this article is the first study of its type to focus on estimating the transmission of dairy product advertising back to the farm level.

The Dairy and Tobacco Adjustment Act of 1983 (DTAA) requires farmers in the 48 contiguous States to pay a 15-cents-per-hundredweight (cwt) assessment on all commercially marketed milk. Up to 10 cents per cwt can be allocated by farmers to regional, State, or local dairy product promotion. The remaining funds are managed by the National Dairy Promotion and Research Board. Over $800 million has been spent on generic dairy advertising and promotion since the implementation of the DTAA. Economic studies (Ward and Dixon, 1989; Kinnucan and Forker, 1986; Thompson and Eiler, 1977; Liu and Forker, 1990)[1] provide evidence of a positive relationship between generic dairy advertising and retail dairy sales. However, only a few studies have examined the impact of advertising on farm-level returns (Liu and others, 1990; Thompson and Eiler, 1977). One reason for this is the complexity of modeling the U.S. dairy industry where raw milk is used in both fluid and manufactured milk products. The farm-level fluid milk price includes a market-determined component, the Minnesota-Wisconsin (MW) price of Grade B milk, and a regulated component (the Class I differential). In general, the farm-level manufactured milk price is a market-determined price. The "blend price" that a farmer receives for his milk is a weighted average of the fluid and manufactured milk prices. The farmer's final receipts are adjusted for miscellaneous costs and payments, such as cooperative expenses, quality and volume premiums, and seasonal incentive payments.

Government intervention, in the form of price support through government purchases of manufactured dairy products, takes place at the wholesale level of the manufactured milk market. Many previous dairy industry studies assume government price supports always hold (Liu and Forker, 1990; Thompson and Eiler, 1977). The application of ordinary least squares (OLS) to these models results in estimates that may be biased and inconsistent (Kmenta, 1986). The study by Liu and others (hereafter referred to as the Cornell study) is the first attempt at explicitly modeling government price support while simultaneously examining the issue of generic advertising effectiveness. In their study, behavioral equations are estimated for retail fluid and manufactured demand, retail fluid and manufactured supply, wholesale fluid and manufactured supply, and farm-level supply. The Cornell model is estimated using a switching regression technique (applying the Heckman procedure for Tobit estimation) that accounts for both free market and price support regimes. Simulation results suggest that fluid milk advertising is more effective in increasing retail demand for milk and its products than is manufactured milk advertising. In addition, farm-level returns are higher when there is advertising only on fluid products ($7.04 per $1 spent) than when there is advertising on both fluid and manufactured products ($4.77 per $1 spent).

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[1] Sources are listed in the references section at the end of this article.

One problem with the Cornell model is that it assumes product quantities at different market levels are the same. This assumption occurs because actual quantities consumed at the retail level are not observable, but instead are measured on a milk-equivalent basis. In econometric analysis of eight disaggregated food commodities (including dairy products as a composite commodity), Wohlgenant (1989) found that the assumption of a fixed-proportions technology between the raw food product and marketing inputs in producing retail products is inconsistent with actual market behavior, producing biased farm-level demand elasticities. In theoretical analysis of distribution of gains from promotion, Wohlgenant (1993) also shows that retail-to-farm linkages of promotional activities are extremely sensitive to the assumption of fixed input proportions.

In view of the limitations of the Cornell model, the modeling approach for this study is based on a partially reduced-form inverse demand formulation of milk prices at the farm level. The conceptual model underlying the derived demand specification includes retail, wholesale, and farm-level supply and demand equations for fluid milk and manufactured milk products. The inverse demand specification for the blend price received by farmers is derived assuming both a competitive regime and a price support regime. The variables that influence the blend price depend on the market regime. For the competitive regime, variables include predetermined market supply of milk, class I price differential, retail demand and supply shifters, wholesale demand and supply shifters, and farm-level demand shifters for the fluid and manufactured market. In the price support regime, support prices for manufactured products would substitute for demand and supply shifters in the manufacturing sector. For this specification, both fluid and manufactured product advertising expenditures affect the blend price under the competitive regime, but only fluid advertising affects the blend price under the support price regime.

In the following sections we present a conceptual framework for modeling effects of dairy products advertising on farm-level demand for milk, quarterly demand relationships which link advertising on fluid and manufactured products with farm-level milk prices, and simulations of the impact of assumed shifts in retail demand from advertising on farm-level milk prices and total revenue of milk producers.

Conceptual Framework

Farm-level demand for milk is viewed conceptually as industry-derived demand for milk as a factor of production in fluid and manufactured dairy products. The conceptual model for industry-derived demand is the reduced-form equation for the farm price of milk, holding the quantity of milk marketed constant (Wohlgenant and Haidacher, 1989, p. 41). In the context of the Cornell model, the equation for derived demand for milk would be derived from the following set of behavioral equations:

$Q_1^d = D_1(P_1, Z_1)$ (wholesale-derived demand for fluid milk) (1)

$Q_2^d = D_2(P_2, Z_2)$ (wholesale-derived demand for manufactured products) (2)

$Q_1^s = S_1(P_1, W_1, V_1)$ (wholesale supply of fluid milk) (3)

$Q_2^s = S_2(P_2, W_2, V_2)$ (wholesale supply of manufactured products) (4)

$X_1 = D_1^x(P_1, W_1, V_1)$ (farm-level demand for fluid milk) (5)

$X_2 = D_2^x(P_2, W_2, V_2)$ (farm-level demand for manufactured products) (6)

$W = (X_1/X)W + (X_2/X)W_2$ (farm-level blend price for milk) (7)

$P_2 \geqslant P_g$ (manufactured price support constraint) (8)

$W_1 = W_2 + DIFF$ (farm-level fluid price) (9)

$Q_1^d = Q_1^s$ (wholesale fluid milk market clearing) (10)

$Q_2^d = Q_2^s - CINV$ (wholesale manufactured market clearing) (11)

$X = X_1 + X_2$ (farm-level market clearing) (12)

In this specification, Q_i^d denotes quantity demanded of the i^{th} wholesale product (i=1 (fluid), 2 (manufactured)), P_i is the market price of the i^{th} wholesale product, Q_i^s denotes quantity supplied of the i^{th} wholesale product, Z_i represents the impact of shifts in wholesale-derived demand, W_i is market price of the i^{th} farm product, V_i represents the impact of shifts in wholesale supply and farm-level demand, X_i is quantity demanded (and supplied) of the i^{th} farm product, X is total quantity of milk marketed (assumed to be predetermined), P_g is the government support price for manufactured dairy products, DIFF is the government-determined price differential between fluid and manufactured milk at the farm level, and

CINV represents government purchases of manufactured products. In this specification, it should be noted that the wholesale demand equations are partially reduced-form derived demand equations, which include the effects of demand and supply shifts at the retail level. These effects are subsumed in Z_1 and Z_2.

The above system of equations can be reduced to four equations in the four prices P_1, P_2, W, and W_1, given the level of government purchases:

$$S_1(P_1, W_1, V_1) = D_1(P_1, Z_1) \tag{13}$$

$$S_2(P_2, W_1\text{-DIFF}, V_2) = D_2(P_2, Z_2) + \text{CINV} \tag{14}$$

$$X = D_1^x(P_1, W_1, V_1) + D_2^x(P_2, W_1\text{-DIFF}, V_2) \tag{15}$$

$$W = W_1 - (\text{DIFF}/X)^* D_2^x(P_2, W_1\text{-DIFF}, V_2), \tag{16}$$

subject to $P_2 \geqslant P_g$. The form of the reduced-form solution for the farm price variable, W, depends on whether the market is operating under the competitive regime or the price support regime. Under the competitive regime, the industry (inverse)-derived demand equation for milk at the farm level has the form,

$$W = f(X, Z_1, Z_2, V_1, V_2, \text{DIFF}). \tag{17}$$

Alternatively, if the price support regime holds, then derived demand has the form,

$$W = g(X, Z_1, P_g, V_1, V_2, \text{DIFF}). \tag{18}$$

Thus, two different specifications for derived demand follow from the operational regime.

An alternative specification for derived demand is obtained by viewing CINV as a latent variable, which theoretically takes on positive, zero, and negative values. This would occur, for example, if CINV was defined as net government purchases, with negative values representing a reduction in government inventory of manufactured dairy products. In this case, we could replace equations 17 and 18 by the following two-equation system:

$$W = W(X, Z_1, Z_2, V_1, V_2, \text{DIFF}, \text{CINV}) \tag{19}$$

$$\text{CINV} = \text{CINV}(X, Z_1, Z_2, V_1, V_2, \text{DIFF}, P_g). \tag{20}$$

These equations are obtained by first solving equations 13-16 for W, given CINV, and then solving equations 13-16 for CINV, given that $P_2 = P_g$.

The comparative statics of equations 19 and 20 are relatively straightforward, given equations 13-16. In particular, it seems reasonable to expect the blend price, W, to increase when farm supply (X) decreases, when wholesale demand for either product Z_1 or Z_2 increases, when marketing costs (V_1 or V_2) decrease, when the Class I differential (DIFF) decreases, and when net government purchases (CINV) increase. We would expect net government purchases to increase when farm supply (X) increases, when wholesale demand (Z_1 or Z_2) decreases, when marketing costs (V_1 or V_2) increase, when the government support price (P_g) increases, and when the differential (DIFF) increases.

Empirical Specification of Demand for Milk

Assume equations 19 and 20 can be represented by equations that are linear in the parameters. Then, in matrix notation, the statistical model can be represented as:

$$Y_1 = a_1 Y_2^* + X_1 B_1 + U_1 \tag{21}$$

$$Y_2^* = X_2 B_2 + U_2, \tag{22}$$

where $Y_2 = Y_2^*$ if $Y_2^* > 0$, but $Y_2 = 0$ otherwise. These equations are the statistical counterparts to equations 19 and 20. Y_1 is the vector of observations on the blend price, Y_2^* is the latent variable corresponding to net government purchases, X_1 is the matrix of observations on the demand and supply shifters in the price equation, X_2 is the matrix of observations on the demand and supply shifters in the net government purchases equation, and U_i (i=1,2) is a nonautocorrelated random disturbance term with zero mean and constant variance.

Equations 21 and 22 represent a simultaneous equations model with one limited endogenous variable, Y_2. These equations are estimated using Amemiya's principle (Judge and others, 1985, pp. 785-89), which is asymptotically more efficient than traditional two-stage estimation methods. In this case, the procedure is implemented through estimating equation 22 by Tobit analysis, and estimating the reduced-form equation for Y_1 by least-squares. The reduced-form parameter estimates corresponding to Y_1 are then regressed on the parameter estimates of the Tobit equation corresponding to Y_2^* and on an appropriately constructed matrix of ones and zeros, showing the relationship between the reduced form and structure associated with equations 21 and 22 (Judge and others, 1985, p. 787).

Equations 21 and 22 are estimated subject to a set of cross-equation restrictions, specifically,

$$B_{1i} = -a_1 B_{2i}, \quad (23)$$

where B_{1i} and B_{2i} are coefficients associated with the variables X_{1i} and X_{2i}, when $X_{1i} = X_{2i}$ and when X_{1i} represents a shift in wholesale-derived demand for manufactured dairy products. In this way, generic advertising for manufactured products is restricted to have zero impact on farm price when the support price for manufactured products is binding. In general, the effect of imposing these cross-equation restrictions is to produce two estimated derived demand structures, one consistent with the competitive regime and the other with the price support regime. When the competitive regime holds, $Y_2^* = 0$ and X_1 represents all demand and supply shifters. However, when the price support regime holds, $Y_2^* > 0$ and equation 21 has support prices for manufactured products instead of wholesale-derived demand shifters for the manufactured products. Thus, by alternatively selecting $Y_2^* = 0$ or $Y_2^* > 0$, we can isolate the demand structure corresponding to the competitive regime (equation 17) or the price support regime (equation 18).

Econometric Results

Quarterly data for 1975 are used in the estimation of equations 21 and 22. Definitions of the variables and data sources are shown in table 1. Advertising data, which are the sum of generic and branded advertising by product class, come from *Leading National Advertisers* (1975-90). These data are real advertising quantities made available by Blaylock through ERS. All variables other than for government purchases are in natural logs. All nominal

Table 1—Variable definitions and sources

Variable	Definition	Source
BCINV	Beginning commercial inventory, billion lbs. milk equivalent	Cornick et al.
CPI	Consumer Price Index, all items, 1982-84 = 100	Cornick et al.
DIFF1	Class 1 differential, $/cwt.	Cornick et al.
FARMPR	Farm milk price, cents/lb.	Cornick et al.
FMSUP	Farm milk production, billion lbs.	Cornick et al.
FUEL	Producer price index for fuel related products and power 1982-84 = 100	Cornick et al.
FUSE	Onfarm use of milk, billion lbs.	Cornick et al.
GOVQ	Net government removals, billion lbs.	Cornick et al.
INC	Pesonal consumption expenditures	Cornick et al.
NONALC	Nonalcoholic beverages; retail price index, 1982-84 = 100	Cornick et al.
POLICY	Dummy variable for the dairy termination	
POP	U.S. population	Cornick et al.
PPBNF	Government support price for butter, nonfat, cents/lb.	Cornick et al.
PPC	Government support price for cheese, cents/lb.	Cornick et al.
Q2, Q3, Q4	Dummy variables for quarters 2, 3, 4	
RADFL	Total fluid milk advertising expenditures, $1,000	Leading National Advertisers
RADMN	Total manufactured milk advertising expenditures, $1,000	Leading National Advertisers
RBUT	Total butter advertising	Leading National Advertisers
RCHS	Total cheese advertising expenditures, $1,000	Leading National Advertisers
RFDAWAY	Food consumed away from home; retail price index, 1982-84 = 100	Cornick et al.
RFRZ	Total frozen dairy advertising expenditures, $1,000	Leading National Advertisers
ROTHER	Total other dairy advertising expenditures, $1,000	Leading National Advertisers
TIME	Linear time trend (first quarter of 1976 = 1)	
WAGEMAN	Wholesale trade average hourly earnings index, 1982-84 = 100	Cornick et al.

variables are deflated by the Consumer Price Index for all items. Quarterly dummy variables and a linear time trend are included in each regression.

In previous studies, the switching points from the competitive to the price support regimes were identified by comparing a weighted average wholesale price for manufactured products with a weighted average government purchase price. If the average purchase price was less than the average wholesale price, government purchases were set to zero; otherwise, government purchases were equal to observed purchases. The problem with this approach is that identification of particular regimes is sensitive to the weights chosen in constructing the average wholesale and purchase prices. Also, conceptually, government purchases occur whenever the support price for an individual commodity is greater than its wholesale price. Thus, in the current study, competitive and price support regimes are identified by examining the relationship between the wholesale and the purchase price for butter, nonfat dry milk, and cheese, the major products purchased by the Government. If in any quarter the purchase price for any product exceeds its wholesale price, the price support regime is assumed to be in effect; otherwise, the competitive regime is assumed to hold.

By this procedure, we identify that the price support regime was in effect 68 percent of the time. Liu and others (1990) use average purchase and wholesale prices over all manufactured products and find the price support regime was in effect 58 percent of the time from 1975 (Q1) through 1987 (Q4). While purchase prices for three products (butter, nonfat dry milk, and cheese) are used to identify regimes, butter and nonfat dry milk are aggregated for the estimation because of multicollinearity and a wrong sign obtained on the nonfat dry milk price variable in initial estimations.

Consistent with the Cornell model and previous work by Ward and Dixon (1989), we assume advertising affects behavior in the current and subsequent four quarters, and we restrict the coefficients of the lag distribution by specifying a second-order polynomial lag with endpoint restrictions. With this specification, we lose the initial 4 observations, leaving a total of 60 observations 1976 (Q1) to 1990 (Q4).

Econometric results are presented for two sets of advertising variables. In the first set, we aggregated all manufacturing advertising into a single variable, one representing the effects of fluid advertising and the other, manufactured advertising (table 2). In the second set, manufactured advertising is disaggregated (butter, cheese, frozen, and other products), and these advertising variables are added to the fluid milk variable (table 3). In tables 2 and 3, the first column lists the variables (defined in table 1), the second column shows the coefficient estimates of the government purchase equation 22 estimated by Tobit, and the third column shows the coefficient estimates of the farm price equation 21 estimated by the Amemiya procedure.[2] Values in parentheses are asymptotic t-values.[3] All computations were performed using version 6.2 of SHAZAM (White and others, 1990).

In table 2, we see general conformity between theory and estimation. In the equation predicting net government purchases, the farm supply variable and support prices have positive signs. The key demand shift variables, current and lagged fluid and manufacturer advertising, are negatively related to government purchases, as expected. Some other variables in the equation may have incorrect signs, but theory is not precise on what sign to expect.[4] Three of the most significant variables are income, time, and the effect of the dairy termination buyout programs. The squared correlation between observed and expected values of this equation (not reported in table 2) is 0.88.

Estimates of derived demand for raw milk at the farm level are reported in the last column of table 2. The elasticity of farm price with respect to the quantity of milk supplied (own-price flexibility) is less than one in absolute value, suggesting an elastic own-price elasticity of demand. This is not

[2]In the first stage of the Amemiya estimation procedure, correction was made for fourth-order autocorrelation in the residuals of the unrestricted reduced-form price equation.

[3]The t-statistics for the coefficients in the farm price equations were computed from standard errors using White's heteroskedastic-consistent covariance estimation method to correct for a general, unknown form of heteroskedasticity. The reason the standard errors were corrected for heteroskedasticity is that the error term in the second stage of the Amemiya procedure is heteroskedastic. The correct, but computationally more complex, formulas for the asymptotic coefficient standard errors are provided by Amemiya. Thus, the standard errors (and hence, t-statistics) computed using White's method must be viewed as approximations to the true values.

[4]Specifically, depending upon whether the goods are substitutes or complements, we would expect different signs on the price variables in the reduced-form rice equation. This is true both for retail prices of related goods and for marketing input prices. The variables NONALC, RFDAWAY, and RMEAT are included to represent the impact of retail prices of related goods on retail demand for fluid and manufactured dairy products. FUEL and WAGEMAN are included to account for changes in costs of manufacturing and marketing dairy products. The variable BCINV is included to represent the effects of commercial inventory holdings of dairy products.

Table 2—Econometric results for total advertising model with disaggregate support prices

Variable	Government purchases		Farm price	
FMSUP	17.575	(1.6317)	–0.7247	(–4.5058)
RADFL	–0.1228	(–0.9177)	0.0120	(10.658)
RADFL1	–0.1965	(–0.9177)	0.0192	(10.658)
RADFL2	–0.2211	(–0.9177)	0.0216	(10.658)
RADFL3	–0.1965	(–0.9177)	0.0192	(10.658)
RADFL4	–0.1228	(–0.9177)	0.0120	(10.658)
RADMN	–0.1514	(–0.5110)	0.0019	
RADMN1	–0.2422	(–0.5110)	0.0030	
RADMN2	–0.2725	(–0.5110)	0.0034	
RADMN3	–0.2422	(–0.5110)	0.0030	
RADMN4	–0.1514	(–0.5110)	0.0019	
PPBNF	5.2220	(1.6496)		
PPC	19.634	(2.8569)		
DIFF1	7.8761	(1.0910)	–0.5660	(–7.8526)
FUSE	0.4841	(0.1607)	–0.2941	(–66.384)
FUEL	–0.1447	(–0.0389)	–0.0352	(–26.595)
NONALC	–1.9605	(–0.8414)	0.0716	(3.9884)
RFDAWAY	9.0292	(0.6670)	–0.1122	
RMEAT	–5.9507	(–1.2550)	0.0740	
INC	–26.219	(–2.7833)	–0.7764	(–3.2355)
WAGEMAN	23.204	(1.1037)	1.4150	(6.6635)
TIME	0.5833	(2.6613)	0.0048	(0.8984)
BCINV	5.6539	(2.6423)	–0.0823	(–1.5907)
POP	–39.921	(–0.9625)	–3.0111	(–8.2418)
Q2	–0.4866	(–0.4869)	0.0413	
Q3	–2.6720	(–3.6995)	0.0614	
Q4	–0.3523	(–0.3903)	0.1090	
POLICY	–1.5294	(–2.6974)	0.0236	(1.6858)
GOVQ			0.0124	(1.3584)
CONSTANT	707.21	(0.8851)	56.869	
LOG LIKELIHOOD VALUE	–60.728508			

Note: All variables except GOVQ and the dummy variables are in natural logarithms. The variable definitions are given in table 1. The advertising variables (for example, RADFL, RADFL1, RADFL2, RADFL3, RADFL4) represent effects in the curren quarter and the previous four quarters. Values in parentheses represent asymptotic t-values.

consistent with previous work suggesting inelastic demand (for example, Wohlgenant and Haidacher, 1989). However, with quarterly data, greater possibilities for storage by the commercial sector can lead to a more elastic demand response (Pasour and Schrimper, 1965). A comparison with the results in table 3, which shows that demand is less elastic when manufactured advertising is disaggregated, suggests that the estimate of own-price flexibility of milk is sensitive to aggregation of the manufactured advertising variables.

Both fluid and manufactured advertising have the correct signs.[5] Except for population, which we would expect to be positive, it is hard to predict the signs of the other variables in this equation.[6]

The advertising elasticities in the farm price equation appear to be reasonable, especially the fluid advertising elasticities. The sum of the fluid advertising effects is 0.084, indicating that over the period of a year, a sustained increase of 10 percent in fluid advertising would increase farm price 0.84 percent. If manufactured advertising is added to fluid advertising, the elasticity becomes 0.097. Both of these estimates are near the elasticity of 0.05 computed by Wohlgenant (1991). The larger relative magnitude of the fluid (vs. manufactured) advertising variable, is consistent with the relative effects on retail demand estimated by Liu and others (1990).

[5]In the price equation, the coefficients on the manufacturing advertising variables (as well as the support price variables and the two retail price indices, RFDAWAY and RMEAT) are constrained to equal the coefficient on the government purchase variable (0.012432) multiplied by the negative of the respective coefficient in the government purchase equation (see equation 23).

[6]Includes income, which has been found to be negative in many studies.

Table 3—Econometric results for disaggregate advertising model with disaggregate support prices

Variable	Government purchases		Farm price	
FMSUP	25.640	(2.2518)	–0.9625	(–11.422)
RADFL	–0.2700	(–1.7403)	0.0185	(20.804)
RADFL1	–0.4320	(–1.7403)	0.0295	(20.804)
RADFL2	–0.4860	(–1.7403)	0.0332	(20.804)
RADFL3	–0.4320	(–1.7403)	0.0295	(20.804)
RADFL4	–0.2700	(–1.7403)	0.0185	(20.804)
RBUT	0.1202	(0.8185)	–0.0008	
RBUT1	0.1923	(0.8185)	–0.0013	
RBUT2	0.2164	(0.8185)	–0.0014	
RBUT3	0.1923	(0.8185)	–0.0013	
RBUT4	0.1202	(0.8185)	–0.0008	
RCHS	–0.4768	(–1.5407)	0.0031	
RCHS1	–0.7628	(–1.5407)	0.0050	
RCHS2	–0.8582	(–1.5407)	0.0056	
RCHS3	–0.7628	(–1.5407)	0.0050	
RCHS4	–0.4768	(–1.5407)	0.0031	
RFRZ	0.1041	(0.4526)	–0.0007	
RFRZ1	0.1665	(0.4526)	–0.0011	
RFRZ2	0.1873	(0.4526)	–0.0012	
RFRZ3	0.1665	(0.4526)	–0.0011	
RFRZ4	0.1041	(0.4526)	–0.0007	
ROTHER	0.1307	(0.5036)	–0.0009	
ROTHER1	0.2091	(0.5036)	–0.0014	
ROTHER2	0.2352	(0.5036)	–0.0015	
ROTHER3	0.2091	(0.5036)	–0.0014	
ROTHER4	0.1307	(0.5036)	–0.0009	
PPBNF	6.9175	(1.8554)		
PPC	14.131	(1.9349)		
DIFF1	4.3491	(0.5290)	–0.1922	(–13.445)
FUSE	–2.2957	(–0.6618)	–0.0839	(–11.122)
FUEL	1.8406	(0.4270)	–0.0054	(–0.8850)
NONALC	–2.4285	(–1.0634)	0.0995	(12.472)
RFDAWAY	13.906	(0.9842)	–0.0914	
RMEAT	0.1730	(0.0270)	–0.0011	
INC	–32.886	(–3.3186)	–0.7972	(–7.3765)
WAGEMAN	22.561	(0.8535)	2.4016	(32.391)
TIME	0.6146	(2.6292)	0.0063	(3.0948)
BCINV	6.9407	(2.9380)	–0.0037	(–0.1608)
POP	–62.466	(–1.4551)	–1.0189	(–4.9631)
Q2	–0.7859	(–0.7699)	0.0579	
Q3	–2.7068	(–3.6020)	0.0419	
Q4	0.4641	(0.4780)	0.0816	
POLICY	–0.8954	(–1.4226)	–.0008	(–0.2628)
GOVQ			0.0066	(1.994)
CONSTANT	1128.4	1.3748	20.299	
LOG LIKELIHOOD VALUE	–58.684650			

Note: All variables except GOVQ and the dummy variables are in natural logarithms. The variable definitions are given in table 1. The advetising variables (for example, RADFL, RADFL1, RADFL2, RADFL3, RADFL4) represent effects in the current quarter and the previous four quarters. Values in parentheses represent asymptotic t-values.

These advertising elasticities are for the dairy sector under a competitive regime. Under the price support regime, the effect of manufactured advertising is constrained to be zero. (When a change in manufactured advertising induces a change in government purchases, this effect cancels out the direct effect of a change in manufactured advertising.) The effect of fluid advertising (over four quarters) is now 0.073 compared with 0.084 when the competitive regime holds.[7]

The results in table 3 are very similar in sign and magnitude to those in table 2 except for some disaggregated advertising effects. For example, butter, frozen, and other products have incorrect signs in both equations, but their effects are insignificant in the government purchase equation. Own-price flexibility is larger in absolute value in

[7]The own-price flexibility of milk would be smaller (–0.51 compared with –0.72) when the competitive price regime holds.

This is consistent with Marshall's rule that derived demand for a factor will be more elastic (smaller price flexibility) the more elastic demand is for the product. Since demand for all milk products is more elastic (at the wholesale level) when the price support scheme is operational, demand for milk at the farm level is more elastic, which is what we observe.

this specification compared with the one in table 2. The effects of fluid advertising are also slightly larger in this specification.

To discriminate between the disaggregated and aggregate advertising models, we employ the Akaike Information Criteria (AIC) (Harvey, 1990, pp. 177-78). This criteria was applied to the unrestricted reduced-form price equations for each model and a smaller AIC was obtained for the second model, indicating the model with disaggregated variables is preferred.[8]

Model Validation

To determine the validity of the estimated econometric structure (equations 21 and 22) for simulating the effects of changes in advertising, static simulations were conducted with the reduced form to see how well the model replicated historical values of the endogenous variables. Because the Tobit model is used to predict the (unobserved) latent variable, net government purchases, the validity of the model is solely assessed in terms of predicting the farm price of milk.

Initial efforts to generate historical forecasts of the farm price variable were unsuccessful, with the predicted price consistently exceeding the actual price by a large, relatively fixed amount. This suggests that the estimated intercept values obtained by the Amemiya procedure are badly biased. Although the Amemiya procedure, which is a quasi-maximum likelihood procedure, yields econometric estimates that are consistent, there is no assurance that the historically predicted residuals should have a zero mean as would be the case with any least-squares procedure. At the same time, it is not necessary to restrict the intercept of the reduced-form price equation. Thus, to ensure that the historically predicted residuals have a zero mean, only the nonintercept coefficients (which exclude the constant plus the quarterly dummies) were estimated by the Amemiya procedure.

Given estimated values for the nonintercept coefficients, the residuals, formed by subtracting the sum of the variables multiplied by these coefficient estimates, were regressed on the constant and three dummy variables to obtain predicted residuals for the reduced-form price equation that have a zero mean. As there was evidence of serial correlation when estimating the unrestricted reduced-form price equation in stage 1 of the Amemiya procedure, the estimates were also corrected for fourth-order autocorrelation. The constant and quarterly dummy variable estimates of the farm price equation (reported in tables 2 and 3) produce zero means for the historically predicted residuals.

Using parameters estimated by the above procedure, historical simulations were conducted for both the aggregate manufactured advertising model and the disaggregate manufactured advertising model. The root-mean squared errors of the forecasts are 1.11 cents per pound (aggregate) and 1.09 cents per pound (disaggregate). With a sample mean real milk price of 13.35 cents per pound, the coefficients of variation are 0.083 (aggregate) and 0.082 (dissaggregate).

Impact of Advertising

Both models were also used to simulate the effects of increased advertising over time on the farm price of milk and on total revenue of milk producers. To determine the impact of advertising on farm revenue since 1983, historical forecasts of the real farm price were compared with forecasts holding advertising constant in real terms from 1983 (Q4) through 1990 (Q4). Since advertising affects price with a time lag, comparisons began with the fourth quarter of 1984.

The effect of increased advertising on farm revenue was calculated by dividing the change in total revenue by the change in advertising.[9] (Since the quantity of farm production of milk is taken as fixed, the change in total revenue is simply the sum of the changes in price weighted by the actual quantities.) By this procedure, we obtain farm-level rates of return to advertising of 2.56:1 and 6.00:1 for the aggregated and disaggregated models. These estimates are in the range of the estimate of 4.77:1 obtained by Liu and others (1990).

Summary and Conclusions

To estimate the effects of changes in dairy product advertising on farm prices, we constructed a model

[8]Use of a conventional F-statistic to test whether aggregating all manufactured advertising variables together is too restrictive is inappropriate because the two models are non-nested. Use of a non-nested hypothesis test leads to four possible outcomes, including acceptance and rejection of both models. Indeed, application of Davidson and MacKinnon's J-test, while indicating rejection of the aggregate manufactured advertising specification when that model is the null hypothesis, also indicates rejection of the disaggregated advertising specification when that model is assumed to be the null hypothesis.

[9]To facilitate a comparison with other studies, the change in advertising was calculated as the change in aggregate advertising expenditures deflated by the CPI. In 1982-84 dollars, the change from 1983 (Q4) through 1990 (Q4) was $517,651,337.

with an industry-derived demand equation for milk at the farm level linking advertising and government purchases to farm price, and a government purchases equation linking advertising and support prices to government purchases.

The two-equation model was estimated for both aggregate and disaggregated manufactured advertising. Estimation was performed using quasi-maximum likelihood procedures on the mixed/continuous equation system. The econometric results were generally consistent with theory, indicating significant effects of both fluid and manufactured advertising on farm price. In terms of predictive performance, the model with the disaggregate manufactured advertising variables was preferred.

Both estimated econometric models were used to simulate the impact of increased advertising since 1984. The return on investment to advertising was estimated to be between 2.56:1 and 6.00:1, between $2.56 and $6.00 on each additional dollar spent on advertising 1984 (Q4) to 1990 (Q4). Estimates do not take into account milk supply response; the effects of advertising would likely be different if supply response was included in the simulations.

A model specification for supply response of raw milk at the farm level is needed to calculate more accurately returns on advertising investment. Also, joint estimation of supply response would permit relaxing the assumption that the quantity of milk marketed is predetermined with respect to price in the same quarter. Disaggregation of the advertising variables into generic and branded advertising would permit direct estimation of the effects of generic advertising on milk prices. Finally, more work on specification of variables to represent demand and supply determinants (including alternative distributed lag formulations for the advertising variables) is needed.

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Endogenous Switching Systems: Issues, Options, and Application to the U.S. Dairy Sector

Jorge Cornick and Thomas L. Cox

Abstract. *This research explores the theoretical and applied issues associated with endogenous switching systems where market prices are bounded by policy instruments such as price supports. Options for estimation of model parameters and their associated standard errors are identified and explored. Application to the U.S. dairy sector illustrates the research tradeoffs between conceptual rigor and empirical tractability that characterize these models. Results suggest that failure to explicitly address the endogenous switching context compromises the estimation results.*

Keywords. *Endogenous switching, simultaneous equations, bounded prices, censored variables.*

The econometric analysis of markets where prices are bounded by governmental policies, such as price ceilings, presents certain complications that do not arise when prices are determined by competitive markets. In the simple case of simultaneous supply and demand equations with no market intervention, the endogeneity of prices in the right-hand side of quantity-dependent equations can be accounted for using either two- or three-stage least squares. These methods, however, are not appropriate with bounded prices, and their use yields biased estimators of the parameters in the structural equations.

With bounded prices, more complicated methods are called for. First, the prices that are controlled cannot be estimated using OLS, but require the use of techniques appropriate for limited dependent variables. Second, the conventionally computed second-stage standard errors on the structural parameters are biased (Maddala, 1983). The objectives of this paper are:

To evaluate and compare different estimation methods for systems of simultaneous equations with censored dependent variables; to explore the generalization of methods that are appropriate for models with one censored variable to models with multiple censored variables; and to evaluate the feasibility of using resampling techniques to compute standard errors for second stage coefficients.

We classified estimation methods in two major groups: maximum likelihood methods, in which the parameters of the structural equations are estimated in one step, and two-stage estimation methods which are similar to two- or three-stage least squares. The first stage consists of estimating instruments for the endogenous variables in the right-hand side of the (structural) equations, and in the second stage the instruments are substituted into the structural equations, which are in turn estimated using standard linear or nonlinear regression techniques.

Conventional second-stage standard errors are biased when two-stage estimation methods are used for models with limited dependent variables. The asymptotic theory for a number of such models may be used to compute correct standard errors for the second stage coefficients (Amemiya, 1977, 1978; Lee, 1990; Lee and others, 1980).[1] Such theory is both complicated and not very general (that is, the asymptotic covariance matrices have to be derived again for each permutation of a model that the analyst wishes to investigate). Hence, simulation methods, which are simple and easily generalized, are an attractive alternative. Moreover, the computationally intense nature of these resampling methods can be easily handled in a standard microcomputer context.

The empirical implications of these methodological issues are demonstrated with an application to endogenous switching models of the U.S. dairy industry. We will revisit the work done in endogenous switching (Liu and others, 1980, 1991). Extant empirical work on endogenous switching in U.S. dairy addresses only fluid and a highly aggregated manufactured product sector. The possibility of extending the models to multiple censored variables has not been explored so far. Disaggregate modeling is particularly relevant in the analysis of U.S. dairy policy, as three different dairy products (American cheese, butter, and

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[1] Sources are listed in the references section at the end of this article.

nonfat dry milk) have bounded prices via purchase prices set by the U.S. Government. While previous work has relied on two-stage estimation techniques, only the (biased) second-stage standard errors were reported. Recent efforts by the U.S. Department of Agriculture and the Department of Agricultural Economics at the University of Wisconsin-Madison have provided us with a new set of data that is both more recent (up to 1990, instead of 1987), and in some cases, more reliable than previously used data. In this empirical context two issues arise:

1. Comparison of "bias corrected" versus "not bias corrected" two-stage estimation procedures (see the section on endogenous switching systems). In particular, we discuss the feasibility of generalizing the estimation procedures and examining models with multiple censored variables. If bias correction could be ignored, this generalization would be quite easy.

2. Comparison of conventional second-stage standard errors with bootstrapped standard errors for the parameters of the structural equations. The complexity of the asymptotic theory has led researchers to report conventional second-stage standard errors. Our empirical results indicate that, as expected from theory, the downward bias in the conventional standard errors is not negligible. The good news is that the bootstrap provides a straightforward method for the computation of the second-stage standard errors. Moreover, and in market contrast with asymptotic theory, the bootstrap procedure is very easy to generalize, although occasionally it will only be feasible to bootstrap the second stage of the estimation procedure. In this sense, the bootstrapped standard errors will be conditional on the empirical distribution of the data and the first stage instruments.

Simultaneous Structural Equation Models with Censored Prices

Consider the following set of demand and supply equations, where all variables are expressed as natural logarithms:

$$
\begin{aligned}
q_{it}^{d} &= x_{it}^{d}\ \beta_i^{d} + \alpha_i^{d}\ p_{it} + u_{it}^{d} \\
q_{it}^{s} &= x_{it}^{s}\ \beta_i^{s} + \alpha_i^{s}\ p_{it} + u_{it}^{s}
\end{aligned}
\tag{1}
$$

$$(i = 1,2,...m),$$

where t indicates time period; q_{it}^{d} is the ith demand equation; q_{it}^{s} is the ith supply equation; the x's are row vectors of exogenous variables; p_{it} is the equilibrium price in the ith market; the β's are column vectors of parameters; α's are scalar parameters; and u's are stochastic disturbances with mean zero. In equilibrium, $q_{it}^{s} \equiv q_{jt}^{d} \equiv q_{it}$, and the endogenous variables in the system are the p_{it}'s and the q_{it}'s.

Now introduce support prices in some or all markets in the model. Without loss of generality, assume that the first 1 to k_t markets are in competitive equilibrium at time t, and that support prices are binding for the remaining $k_t + 1$ to m markets. In this case, the equation system in 1 is replaced by:

$$
\begin{aligned}
q_{it}^{d} &= x_{it}^{d}\ \beta_i^{d} + \alpha_i^{d}\ p_{it} + u_{it}^{d} \\
q_{gt}^{d} &= x_{gt}^{d}\ \beta_g^{d} + \alpha^{d}{}_{g}\ p_{gt} + u_{gt}^{d} \\
q_{it}^{s} &= x_{it}^{s}\ \beta_i^{s} + \alpha_i^{s}\ p_{it} + u_{it}^{s} \\
q_{gt}^{s} &= x_{gt}^{s}\ \beta_g^{s} + \alpha_g^{s}\ p_{gt} + u_{gt}^{s}
\end{aligned}
\tag{2}
$$

$$(i = 1,...,k_t)$$
$$(g = k_t + 1,...,m),$$

where $p_{g,t}$ is the support price in the gth market and all other variables are defined the same as equation system 1. At each period t, the first k_t markets are in competitive equilibrium, and the endogenous variables are the equilibrium prices and quantities in each market. The remaining markets are in a government intervention equilibrium, and in those markets, the endogenous variables are the d_{gt}'s and s_{gt}'s, the quantities supplied and demanded in each market. Because private supply and demand are not equal, this type of model is often referred to as a disequilibrium model. Note, however, that private supply and total (private plus government) demand are equal, because the operation of price supports requires that the government purchase the quantities supplied in excess of private demand. In this sense, both regimes are equilibrium regimes. Equations 1 are a special case of equations 2, with $k_t = m$ (that is, no government intervention).

Endogenous Switching Systems: Maximum Likelihood Estimation

Consider the simplest case of equation system 2 where price supports are set for only one market. For periods in which the price support is not binding, let k = m. For periods in which the price support is binding, let k = m-1. Assuming that the disturbances in system 2 are distributed multivariate normal, with mean and variance $(0, \Sigma)$, the joint distribution of the endogenous variables in the system can be found using standard "change of

variable" techniques. Note that the set of endogenous variables is different in the competitive market equilibrium (where all prices and quantities are endogenous) and in the government intervention equilibrium (in which the price in the intervened market is set exogenously, while quantity demanded and quantity supplied are endogenous). When k = m, the log-likelihood, after dropping the constant term, is:

$$\sum_{k=m}\left[-\frac{1}{2}\ln|\Sigma| - \frac{1}{2}(u'\Sigma^{-1}u) + \ln|J_{k=m}|\right], \tag{3}$$

where the summation is over the observations with k = m, u is the stacked vector of disturbances for those observations; and $J_{k=m}$ is the Jacobian of the transformation. Similarly, when k = m-1, the log-likelihood is given by:

$$\sum_{k=m-1}\left[-\frac{1}{2}\ln|\Sigma| - \frac{1}{2}(u'\Sigma^{-1}u^{*}) + \ln|J_{k=m-1}|\right], \tag{4}$$

where the summation now is over the observations with k = m-1; u* is the stacked vector of disturbances for those observations; and the $J_{k=m-1}$ is the corresponding Jacobian of the transformation. Combining equations 3 and 4, we obtain the log-liklihood function for the system:

$$\begin{aligned} L = & \sum_{all}\left[-\frac{1}{2}\ln|\Sigma|\right] \\ & + \sum_{k=m}\left[-\frac{1}{2}(u'\Sigma^{-1}u) + \ln|J_{k=m}|\right] \\ & + \sum_{k=m-1}\left[-\frac{1}{2}(u^{*\prime}\Sigma^{-1}u^{*}) + \ln|J_{k=m-1}|\right]. \end{aligned} \tag{5}$$

The parameter estimates of the structural model can now be obtained, along with an estimate of the covariance matrix of the system, through maximization of equation 5 using numerical methods.

Generalization of this method to multiple censored variables is straightforward. The main difference is that with multiple censored variables the number of equilibria depends on the number of markets in which the price supports are binding at any one time. The log-likelihood function equation 4 would be replaced by a set of functions, each one corresponding to an observed set of combinations of markets in competitive equilibrium and markets in government intervention equilibrium. The log-likelihood function equation 3 would continue to be appropriate for observations in which all markets are in competitive equilibrium. With multiple censored variables, the first two terms on the right-hand side of equation 5 remain unchanged, but the third term is replaced by a set of terms, one for each equilibrium in which at least one price bound is binding.

While this approach is quite simple conceptually (and the convenience of obtaining unbiased estimates of the standard errors is not to be overlooked), empirical implementation is difficult, because unless the covariance matrix is constrained to be diagonal, with each additional market included in the system, the number of parameters to be estimated increases exponentially. At the same time, as the number of censored variables increases, the number of observations corresponding to each equilibrium will diminish (provided that the additional price supports are binding for at least one observation). The net result is an increasingly difficult numerical optimization problem. (See Quandt for a comprehensive discussion of maximum likelihood estimation methods for what he calls "market disequilibrium models.")

The main advantages of the maximum likelihood approach for the estimation of the parameters in an endogenous switching system of simultaneous equations are its conceptual simplicity and the straightforward computation of unbiased standard errors. These advantages should be weighted against some drawbacks. Numerical optimization of equation 5, for example, is far from trivial. To keep the number of structural parameters in the model manageable, imposing restrictive assumptions in terms of the functional forms used may be necessary. These restrictions may be inappropriate in some contexts.

A more important shortcoming is that the maximum likelihood approach does not lend itself easily for the estimation of models with complex error structures. Multivariate normality was the crucial assumption in our previous derivation. If one wishes to entertain serial correlation, in addition to cross-equation correlation between the residuals in the model, the simplicity of the maximum likelihood approach is greatly reduced.[2] This is particularly important if the researcher has reason to believe that serial correlation is present in the model, but has no strong priors about the order of the corresponding ARMA process. One approach that could be helpful here would be to use two-stage procedures to obtain an initial estimate of the model, including the moving average and autoregressive coefficients in each

[2]See the discussion of maximum likelihood estimation of univariate and multivariate ARMA models in Brockwell and Davis.

equation. If, for example, a low-order AR representation seems appropriate for all equations, the "rho transformed" model could be estimated by using maximum likelihood using the "rho transformed" variables.

Endogenous Switching Systems: Two-Stage Estimation Procedures

Again, the discussion begins with single-censored variable models. For this special case, two-stage estimation procedures offer the advantage of considerable computational simplicity. Furthermore, this approach allows the analyst to use complex functional forms and error structures in the estimation of the structural equations. Assuming serially uncorrelated errors in the reduced form equations while at the same time allowing more general error structures in the structural equations, however, may pose questions about the logical consistency of the model. The advantages of two-stage procedures have to be measured against some drawbacks, the most important of which has already been mentioned: the standard errors on the parameter estimates of the structural equations are biased, if computed by conventional methods. The reduced form equations for the observations where k = m are:

$$p_{it} = x_t\pi_i + u_i$$
$$p_{mt} = x_t\pi_m + u_m, \tag{6}$$

where i=1,2....m-1, p_m is the censored price; the p_i are all the other endogenous variables in the model; the x's are row vectors of exogenous variables, and the π's are column vectors of reduced form parameters. The reduced form equations when k = m-1 are:

$$p_{it} = x_{it}{}^*\pi^*{}_i + u^*{}_i, \tag{7}$$

where $x^* = (x, p_{gt})$ and $p_{mt} \equiv p_{gt}$. Denote the probability of an observation belonging to the competitive regime by F(c), where F(c) is the standard normal distribution, and where $c = (p_{g,t} - x_{i,t}\pi)/\sigma$. The probability of an observation being in the government intervention equilibrium is (1-F(c)). The expected value of the censored variable can then be written as:

$$E(p_m) = F(c)^*E\left[p_m \mid p_m > p_g\right] + (1 - F(c))^*p_g, \tag{8}$$

and the conditional expectation as well as F(c) are obtained using a Tobit model.[3] The expected value of the other instruments is given by:

$$E(p_i) = F(c)^*(x\pi_i + E(u_i \mid p_m > p_g))$$
$$+ (1-F(c))^*(x\ ^*\pi_i + E(u^*{}_i \mid p_m \leq p_g))$$
$$= F(c)^*x\pi_i + (1-F(c))^*x^*\pi^*{}_i$$
$$+ F(c)^*E(u_i \mid p_m > p_g)$$
$$+ (1-F(c))^*E(u^*{}_i \mid p_m \leq p_g). \tag{9}$$

Next, examine the two conditional expectations in equation 9. Starting with:

$$F(c)^*E(u_i \mid p_m > p_g)$$
$$= F(c)_* \frac{\mathrm{cov}(u_m, u_i)}{\sigma} * \frac{f(c)}{F(c)}$$
$$= \frac{cov(u_m, u_i)}{\sigma} {}^* f(c). \tag{10}$$

where sigma is the estimated standard deviation from the Tobit model, and f(c) is the density function corresponding to F(c). For the second conditional expectation we use:[4]

$$(1-F(c))^*E(u^*{}_i \mid p_m \leq p_g)$$
$$= -\ (1-F(c))\ * \frac{cov(u^*{}_i, u_g)}{\sigma} * \frac{f(c)}{(1-F(c))}$$
$$= -\ \frac{cov(u^*{}_i, u_g)}{\sigma} {}^* f(c) \tag{11}$$

Use equations 10 and 11 to rewrite equation 9 as:

$$E(p_i) = F(c)^*x\pi_i + (1-F(c))^*\ x\ ^*\pi^*{}_i + cov^{**}\frac{f(c)}{\sigma}$$
$$= x\pi_i + (1-F(c))p_g\pi_g + cov^{**}\frac{f(c)}{\sigma} \tag{12}$$

where cov* is simply the sum of the covariance terms in equations 10 and 11 and is a parameter to be estimated. The last term in equation 12 is similar to Heckman's bias correction term, and it fulfills the same function. In what follows, we will use the expression "bias correction term" to refer to the last term in equation 12.

In contrast with maximum likelihood methods, the generalization of two-stage estimation methods from the single to the multiple censored variables

[3]Note that in equation 8 and in the remaining equations for price expectations the time subscripts are omitted for notational convenience.

[4]Standard results from multivariate normal theory are being used for these derivations. See Johnson and Kotz, 1972, Chapter 36.

case is not straightforward. Computationally it may be more difficult than maximum likelihood estimation. To see this note that with multiple censored variables one could estimate each instrument estimated separately or estimate all instruments simultaneously. With k censored variables, there are 2^k possible equilibrium solutions: the competitive equilibrium solution in all markets, plus all the possible combinations of competitive equilibrium in some markets and government intervention equilibrium in some other markets. Denote these equilibria as E_k, with $k=1,2,...2^k$. The unconditional expected price in market i is the weighted average of the conditional expected prices corresponding to each of the 2^k possible equilibria.

Without loss of generality, let the first c equilibria be such that the price in market i is the competitive equilibrium price, denoted by p_i. In equilibria c+1, c+2,...to 2^k the price support is binding in market i, denoted by $p_{g(i)}$, where the subscript indicates that the price support is binding, and that the price refers to market i. Finally, let $F(E_k)$ denote the probability of the kth equilibria being observed. The unconditional expected price in market i is given by:

$$E(p_i) = \sum_{k=1}^{c} F(E_i)*E(p_i | E_k) + p_{g(i)} \sum_{k=c+1}^{2k} F(E_k). \quad (13)$$

While equation 13 is an expanded version of equation 8, its evaluation is much harder. The reason is that evaluation of the F(.) functions in equation 13 requires integration of the multivariate normal density function over as many variables as price supports are binding in that particular equilibrium. With as little as three such variables, reliable results may be very difficult and time consuming to obtain. More than three binding price supports could make evaluation of equation 13 a practical impossibility, although Monte Carlo integration can always be tried. In addition, the conditional price expectations cannot be obtained with a single equation Tobit model because the conditional distribution for each of the different equilibria will be different. This requires the use of a multiple-equation simultaneous Tobit model.

Similar arguments make the evaluation of the counterpart to equation 9 quite difficult. Note that in evaluating the conditional expectations of the disturbances, the conditioning terms are now the particular equilibria to which the observation belongs. The manipulations in equations 10 and 11 allowed us to derive concise expressions that could then be included in equation 12, but no similar manipulations are available for the more complex conditional expectations in the case of multiple-censored variables. This discussion leads one to question the feasibility of estimating the instrumental variables one by one if there are observations for which more than one price support is binding. Available analytical results and software may allow for this approach for cases with up to three censored variables.

An alternative is to estimate all instruments simultaneously, using a ML approach. Computing the expected prices would require the evaluation of the conditional expectations discussed above (equation 13). Analytical results are currently available for a few special cases of the bivariate and trivariate normal distributions.

An alternative that would still allow estimation of all price instruments simultaneously is to use some probability distribution other than the multivariate normal. In particular, one would be looking for a distribution that has closed-form expressions for the distribution function, and that does not impose undue restrictions on the covariance matrix of the system. The first requirement is nicely fulfilled by several members of the family of multivariate logistic distributions. Unfortunately, these fail the second requirement: severe restrictions are imposed on the structure of the correlation between any pair of variables (Pudney, 1989, p. 295). It is an open question whether the data in a particular application support those restrictions or not. A more general class of functions, the Generalized Extreme Value Functions (GEV's), could be used. Flexible functional forms can be used, so that no unnecessary restrictions are imposed *a priori* on the covariance matrix. To our knowledge very little applied work using GEV's exists, but this might be an alternative worth exploring. The numerical optimization problem of maximizing the likelihood function would still be difficult with GEV's but perhaps more tractable.

Proper estimation of the instruments in a model with multiple censored variables seems to present sufficient difficulties to grant consideration to the following proposal: estimate each censored variable separately with a Tobit model, and compute the expected value as in equation 8. That is, estimate the instrumental variable for each censored variable ignoring whether the other censored variables are at or above the censoring point. Then, estimate the expected value of all other instruments simply by regressing them on the full set of exogenous variables in the model. This implies ignoring the fact that some exogenous variables appear only in some regimes (and ought to be weighted by the probability of observing the regime) as well as ignoring the multivariate equivalent of the bias

correction term in equation 12. This proposal is of interest only in the case of multile censored variables. If there is only one censored variable, proper computation of the instruments is sufficiently straightforward to make consideration of the procedure we just have outlined unnecessary. In the case of multiple censored variables, in contrast, the simplifications gained from ignoring cross-equation information in the estimation of the instruments are considerable. The loss of information that this implies, in a statistical sense, may be more than compensated for by the gain of economic information that could result from considering a more disaggregate model with multiple censored variables.

For illustration purposes, the proper (or biased corrected) and improper (not biased corrected) instruments are contrasted in the empirical section of the paper. The model presented includes only one censored variable, but if ignoring bias correction in this context proved to be of little consequence, one might be more encouraged to ignore it in more complicated models, where such an approach would entail substantial gains in terms of computational simplicity.

Computing Standard Errors for Endogenous Switching Models

There are two ways to approach the problem of computing appropriate standard errors for simultaneous-equation endogenous switching models. First, there is the statistical high road: derive and compute the asymptotic covariance matrix for the particular model specification in which one is interested. Lee and Maddala discuss both general methods that can be used in such derivations and particular cases for which the covariance matrices have been derived. Once the asymptotic covariance matrices have been derived, programming them is not necessarily difficult, but the process can be cumbersome. Moreover, although some very general expressions have been derived, that is, expressions that are valid for a wide class of models with censored or truncated endogenous variables, the covariance matrices for special cases are all different. This means that slight changes in the model specification may require extensive reprogramming of the covariance matrices.

The second approach uses resampling techniques. In particular, any two-stage procedure could be bootstrapped, which would yield estimates of the variance of the structural parameter estimates that result from the empirical distribution of the data and from the particular estimation procedure selected. If the residuals for each regression cannot be assumed to be white noise, the bootstrap resampling should take place from the endogenous and exogenous variables, including all lagged variables in the model.[5] Using the bootstrap implies re-estimating the model for each bootstrap data set. The number of replications in the literature varies, with 200 to 500 replications common. For our empirical application, a conservative approach is followed, and 1,000 replications are used. The instruments were computed only once, and then the second stage of the estimation procedure was bootstrapped. In this sense the bootstrapped standard errors are conditional on the data and the first-stage instruments. The alternative, to bootstrap both the first and second stages, took too long to be feasible.

An Application to the U.S. Dairy Sector

Consider a structural model of the U.S. dairy sector consisting of six equations, as follows:

1) retail demand for fluid milk products;
2) retail demand for manufactured dairy products;
3) retail supply of fluid milk products;
4) retail supply of manufactured dairy products;
5) wholesale supply of fluid milk products; and
6) wholesale supply of manufactured dairy products.

Each equation is specified as linear in the logarithms of the endogenous and exogenous variables. The right-hand side of each equation includes exogenous variables as well as endogenous prices. The specific variables included in each equation are detailed in the tables that follow.

The model has two possible solutions: a market equilibrium solution and a government intervention solution. In the latter, the wholesale price of manufactured dairy products is set by the government. The fluid milk market is always in competitive equilibrium. In the manufactured dairy products market, wholesale demand may fall short of wholesale supply if the purchase price is above the market price. The difference is made up by government purchases (CCC).

Table 1 defines the variables used in the model. The variables QF, FUSE, DINV, and D are treated as exogenous. There are small governmental purchases even when the market price is above the support price. When this happens, CCC also becomes an exogenous variable. The endogenous

[5]When the residuals can be assumed to be white noise, it is customary to resample from the residuals to generate the bootstrap data sets. See Efron (1982).

Table 1—Description of variables used in model

QFL:	retail and wholesale supply and demand of fluid milk products.
QM:	retail supply and demand of manufactured dairy products, wholesale demand of manufactured dairy.
QMWS:	wholesale supply of manufactured dairy products.
PRF:	consumer price index, fluid milk products.
PRM:	consumer price index, manufactured dairy products.
PWF:	producer price index, fluid milk products.
PWM:	producer price index, manufactured dairy products.
P1:	minimum price for class 1 milk.
P2:	minimum price for class 2 milk.
D:	class 1 price differential.
QF:	farm-level milk production.
FUSE:	farm-level milk use.
CCC:	net government removals of manufactured dairy products.
DINV:	change in manufactured dairy product inventories.
C:	intercept term.
A87:	a dummy variable equal to 1 starting in the first quarter of 1988, equal to zero before that.
INT:	A87*LN(PRF/CPI).
CPI:	consumer price index, all items.
BEV:	consumer price index, non-alcoholic beverages.
DFA:	deflated expenditures on fluid milk products advertising.
T:	trend=1,2...
PCE:	personal consumption expenditures.
DMA:	deflated expenditures on manufactured dairy products advertising.
Q i:	dummy variable equal to 1 in quarter i, zero otherwise.
PFE:	producer price index, fuel, energy, and related products.

In addition, the following identities hold:

QMWS=QF-QFL-FUSE.
QM=QF-QFL-FUSE-CCC-DINV.

Last, the following notational conventions are used:

AR(i):	ith "rho" coefficient in an autoregressive process.
LN:	natural logarithm.
LAG(x,i):	variable x, lagged i periods.

variables in the market equilibrium solution are: QFL, PRF, PRM, PWM, PWF, and P2. In the government intervention equilibrium, the endogenous variables are QFL, PRF, PRM, PWF, P2, and CCC. Given the identities defined above there is no need for a separate equation for CCC. Note that the model cannot include separate equations for wholesale demand for fluid milk products and manufactured dairy products because the wholesale demands are identical to the retail supplies. Inclusion of the wholesale demand equations would result in a model with eight equations in six unknowns.

The model is estimated using quarterly data from 1975:1 to 1990:4 (Cornick, Eisenhauer, and Cox, 1992). Since quarterly time series data are used, serial correlation between the residuals is expected. All structural equations are first estimated using ordinary least squares. We compute the residuals for each equation and estimate their correlation and partial correlation coefficients for 12 lags. The results from this exercise are used as a basis to reformulate the time series structure imposed on the error terms of the equations. The results in tables 2-7 correspond to versions of each equation for which there is little evidence of serial correlation in the residuals (with the exception of equation 6, which exhibits fourth-order serial correlation). No correction for serial correlation is made in the estimation of the instruments used in the structural equations. The six-equation model is estimated two different ways: first, using the two-stage procedure described in section 4, and second, estimating the instruments for the censored price using a Tobit model, but the instruments for the other prices are estimated on the full set of exogenous variables, which ignores both the bias correction term and the fact that some variables need to be weighted by the probability of observing the regime in which the variable occurs. In the following discussion, the first procedure is referred to as "bias corrected" and the second approach as "not bias corrected." The objective of comparing these two procedures is to evaluate the impact of bias correction on the regression results.

For the bias corrected model, standard errors for all structural coefficients are also computed in two different ways: the conventional standard errors are computed at the second stage; and the model is bootstrapped with computed standard errors after 1,000 replications of the model. The objective of this comparison is to evaluate the expected downward bias in the nonbootstrapped standard errors.

Table 2 presents the results for the retail fluid demand equation, which is estimated as a function of retail fluid price, retail price of nonalcoholic beverages, and personal consumption expenditures (all deflated by the retail CPI for all items), the deflated advertising expenditures for fluid milk products, lagged demand, plus several dummy variables. Parameter estimates are almost identical with and without bias correction, with one important exception: the own price coefficient is -0.037 without bias correction and it increases to

Table 2—Retail fluid demand

	Not bias corrected	Bias corrected		
	Parameters	Parameters	Second Stage t-values	Bootstrap t-values
C	–1.591	–1.563	–4.870	–5.604
A87	0.023	0.029	1.787	1.458
INT	0.245	0.296	2.130	1.637
LN(PRE/CPI)	–0.037	–0.067	–0.944	–0.999
LN(BEV/CPI)	–0.016	–0.016	–1.814	–1.628
LN(PCE/CPI)	0.185	0.185	4.066	4.568
LN(DFA)	0.003	0.003	0.833	0.926
T	–0.003	–0.003	–4.667	–4.538
Q1	–0.027	–0.027	–3.151	–3.515
Q2	–0.070	–0.070	–11.339	–12.017
Q3	–0.043	–0.043	–12.286	–14.052
LAG(RFD,1)	0.501	0.507	5.196	6.001

-0.067 with bias correction. All coefficients have the expected signs, but note the use of a dummy variable for observations after 1987, and an interaction term including the dummy and the own-price coefficient. Dropping the dummy and interaction term resulted in a change of sign in the own-price coefficient. Use of the second-stage t-values or the bootstrapped t-values seems to make little difference. The coefficient "INT" loses significance at conventional levels when the bootstrapped t-values are used, but this is a variable of little economic interest.

Table 3 presents the results for retail manufactured demand, which is estimated as a function of own price and personal consumption expenditures (both deflated by the retail CPI for all items), deflated advertising expenditures on manufactured dairy products and dummy variables for the second and third quarters. The equation is estimated as an AR(2) process. Demand seems slightly more inelastic if the bias corrected own-price coefficient is used instead of the not-bias-corrected one. Perhaps more significant is the change in the coefficient on advertising expenditures: the elasticity of demand with respect to advertising is estimated to be 0.012 without bias correction, and it drops almost 50 percent, to 0.007, with bias correction. The t-values are virtually identical with and without using the bootstrap.

Table 4 presents results for retail fluid supply, estimated as a function of retail price and the price of fuel and energy, with both deflated by the wholesale price of fluid milk products. Quarterly dummies and a time trend were included in the equation, which was estimated as an AR(1) process. All coefficients have the expected signs and are virtually identical with and without bias correction. Note, however, that statistical inferences change for the energy price and trend coefficients if the bootstrapped t-values are used instead of the conventional second stage t-values. In both cases, the coefficients are statistically significant at conventional levels according to the second-stage t-values, and not statistically significant according to the bootstrapped t-values.

Table 5 shows the results for retail manufactured supply, estimated as a function of own price and the price of fuel and energy, both deflated by the wholesale price of manufactured dairy products. A time trend and quarterly dummies are included in the equation, which is estimated as an AR(2,4) process. Note that the supply response is more inelastic according to the bias-corrected parameter estimates, and that the AR(3) coefficient is more

Table 3—Retail manufactured demand

	Not bias corrected	Bias corrected		
	Parameters	Parameters	Second Stage t-values	Bootstrap t-values
C	–3.428	–3.405	–19.769	–15.202
LN(PRM/CPI)	–0.112	–0.094	–0.737	–0.579
LN(PCE/CPI)	0.426	0.430	5.685	5.468
LN(DMA)	0.012	0.007	0.389	0.410
Q2	0.046	0.043	2.260	2.307
Q3	0.010	0.004	0.193	0.204
AR(2)	–0.591	–0.581	–5.376	–4.683

Table 4—Retail fluid supply

	Not bias corrected	Bias corrected		
	Parameters	Parameters	Second Stage t-values	Bootstrap t-values
C	2.656	2.632	107.981	7.545
LN(PRF/PWF)	0.221	0.254	1.654	0.886
LN(PFE/PWF)	–0.038	–0.043	–4.182	–1.229
Q1	–0.045	–0.041	–6.155	–5.223
Q2	–0.084	–0.079	15.370	–11.856
Q3	–0.051	–0.051	–15.781	–17.312
T	0.001	0.001	4.410	0.639
AR(1)	0.581	0.485	4.469	3.609

Table 5—Retail manufactured supply

	Not bias corrected	Bias corrected		
	Parameters	Parameters	Second Stage t-values	Bootstrap t-values
C	2.643	2.582	37.963	13.042
LN(PRM/PWM)	0.205	0.126	1.442	0.933
LN(PFE/PWM)	–0.051	–0.050	–1.550	–1.129
Q1	–0.078	–0.057	–2.253	–1.890
Q2	0.034	0.036	1.286	1.275
Q3	0.022	–0.006	–0.192	–0.160
T	0.005	0.005	9.972	1.798
AR(2)	–0.162	–0.375	–2.792	–2.221
AR(4)	0.276	0.245	1.833	1.470

than twice as large according to the bias-corrected estimates. The coefficients on the first quarterly dummy and on the time trend are statistically significant at conventional levels using second-stage t-values, but lose that significance if the bootstrapped t-values are used.

Wholesale fluid supply results are presented in table 6. Supply is estimated as a function of own price and price of fuel and energy, both deflated by class 1 price. Quarterly dummies, a time trend and lagged supply, are also included in the equation. All the coefficients have the expected signs, and are almost indistinguishable regardless of the estimation method used. The t-values present an anomalous pattern for this equation, in the sense that the bootstrapped t-values are generally larger than the second-stage t-values, contrary to what was expected. However, in all cases, inferences concerning significance at conventional levels are the same regardless of the set of t-values used.

Wholesale manufactured supply results are presented in table 7. The equation is very similar to the wholesale supply equation, and the regressors are own price and price of fuel and energy, both deflated by class 3 prices. Two quarterly dummies, a time trend and lagged supply are included in the equation. As in other equations, most parameter estimates are very similar regardless of estimation method. Moreover, the own-price coefficient changes by about a third and has the wrong sign

Table 6—Wholesale fluid supply

	Not bias corrected	Bias corrected		
	Parameters	Parameters	Second Stage t-values	Bootstrap t-values
C	1.255	1.239	4.707	5.606
LN(PWF/P1)	0.047	0.053	2.445	6.613
LN(PFE/P1)	–0.022	–0.020	–2.400	–3.138
Q1	–0.044	–0.044	–6.922	–8.406
Q2	–0.081	–0.082	–16.020	–18.075
Q4	–0.052	–0.052	–17.400	–20.551
T	0.000	0.000	1.000	1.319
LAG(WFS,1)	0.529	0.537	5.147	6.149

Table 7—Wholesale manufactured supply

	Not bias corrected	Bias corrected		
	Parameters	Parameters	Second Stage t-values	Bootstrap t-values
C	2.739	2.754	73.150	3.721
LN(PWM/P3)	−0.312	−0.472	−2.389	−12.975
LN(PFE/P3)	0.179	0.181	5.234	3.316
Q2	0.145	0.154	11.835	13.535
Q4	−0.089	−0.095	−8.556	7.688
T	0.006	0.007	13.088	9.849
LAG(WMS,1)	0.345	0.358	5.444	6.245

(implying negatively sloped supply) despite repeated attempts to obtain more reasonable results. This, perhaps, reflects the high level of aggregation in this manufactured dairy product category. No statistical inferences are changed if the bootstrapped t-values are used instead of the second-stage t-values.

Summary and Conclusions

Regardless of whether the analyst chooses a one-step or a two-step procedure, the use of maximum likelihood methods seems to be the only satisfactory alternative. A special difficulty associated with maximum likelihood estimation of the instruments in the presence of multiple censored variables was the need for multiple integration of a multivariate probability density function. Using a multivariate normal probability density function may render this problem intractable. In this context, the use of alternative closed form distribution functions, such as the Generalized Extreme Value Functions, may prove useful. Univariate Tobit models and ordinary least squares regressions could be used to generate starting values for the maximum likelihood estimation.

The main conclusions that can be derived from that application are quite modest. First, when bias correction is ignored we found the resulting bias in the parameter estimates to be quite small with few exceptions. Computational simplicity, in the context of these data and model, may be a sufficient argument to recommend use of methods that ignore bias correction. However, the generality of these results for other research contexts, particularly those with multiple market endogenous switching, is an open question. Second, while we also found the bias associated with conventional second stage standard errors to be rather small, either asymptotic theory or resampling techniques should be used to generate correct second stage standard errors. The use of the bootstrap was illustrated, and the simplicity and generality of the approach were emphasized.

Several areas require further research. Our analysis indicates that the dynamic specification of the dairy sector model is particularly important, yet we derived that specification in an *ad hoc* fashion. While considerable research on dairy sector dynamics has been carried out at the farm level, it seems necessary to extend that research into the dynamics of the wholesale and retail components of the dairy sector.

Our analysis was carried out entirely in terms of an aggregate "manufactured dairy products" category. In contrast, the U.S. dairy price support program operates through purchase prices for three different manufactured dairy products: butter, American cheese, and nonfat dry milk. Therefore, to evaluate more fully the effects of the operation of the price support program, the analysis should be performed at a more disaggregate level. To do this, it will be necessary to explore several possibilities: estimate the instruments in multiple-censored variable models using maximum likelihood techniques; maximum likelihood estimation of the structural equations, possibly after using the "not bias corrected" approach to generate both starting values and hypotheses concerning the time series structure of the residuals in the model. Neither of these alternatives will be easy or straightforward. The potential lack of generality of the research results presented here, particularly for multiple market endogenous switching models, suggests we need to further evaluate these alternatives.

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The Power of Possession

Land and Law in California: Essays on Land Policies. *By Paul W. Gates. Ames, IA: Iowa State University Press, 1991, 386 pages, $37.95.*

Reviewed by Gene Wunderlich

For economists who labor under the assumption that government's laws and rules make some difference in an economy, *Land and Law in California* is healthy support. The book is a mother lode of historical documentation on the claims to, and settlement of, lands of the Golden State beginning with the Mexican land grants and the argonautic migration of the mid-19th century. Gates shows how the exploitation, manipulation, and application of public law on landownership affected the pattern of agricultural development in California. He contrasts the patterns of California with other states and regions.

The unifying concept one draws from the 13 separate essays of Gates' book is that the two decades of tumultuous lawmaking and lawbreaking following Mexico's 1846 cession of California to the United States set the pattern of agriculture today. The book ends with a chapter on corporations in the current structure of agriculture, including vignettes on the Tejon Ranch and Kern County Land Company. Although the last of the essays was published in 1978, the historical significance of early ownership patterns to today's agriculture in California remains.

The essence of the land issue in California was the struggle between the latifundistas, those who acquired large estates in part from Mexican land grants, and the squatters, many of whom had been drawn to the state by the prospect of gold. The struggle took place in a chaotic institutional environment. One source of difficulty was the land grants issued by the beleaguered Mexican government in the final moments before California was transferred to the United States. Problems arose in interpretation of Mexican grants into American law, the application of American law as illustrated by the Suscol principle, and the settlement of the conflicting claims through the courts and special legislation.

A substantial part of the Mexican land grant problem can be labelled a boundary problem. Most of 813 grants made by the Spanish and Mexican governments were made in large tracts of land, unsurveyed and imprecisely located. About 750 of these grants were ranchos of 1 to 11 square leagues (a square league is 4,436 acres) with a total of 14 million acres of some of the best land in the territory. Property lines were unmarked, poorly described, often overlapping. Most was grazing land. Most titles were not fee-simple and grantees did not have the right to alienate their land. In general, the Spanish and Mexican grants did not match the Anglo-American title system or the settler's expectations. The rapid migration by squatters expecting to preempt land by occupation, cultivation, and construction on land poorly identified as grant land inevitably resulted in conflict.

The turmoil in claims by grantees and squatters found its way into the courts where entrepreneurs with strong legal counsel firmed their possession of vast holdings. The administration of the California Land Act of 1851 was at first extremely permissive and some large holdings were confirmed even in the face of fraud. One such claim, the Suscol, led to legislation allowing buyers of defective claims to retain their lands and exempt them from the 160-acre limitation of preemption laws. Following the Suscol affair, according to Gates, a distracted Congress enacted legislation allowing the creation of huge estates out of state school and improvement lands. The pace of settlement, the pressure on Congress and the administration before and during the Civil War, and the enterprise of land barons, which Henry George described as "greed, ... corruption and high handed robbery," resulted in a pattern of uneven landholding that remains today.

The land boom of California created fortunes and poverty, witnessed and critiqued by Henry George. George combined Ricardian economics and journalistic fervor to produce *Our Land and Land Policy* (1871) and later the widely read classic *Progress and Poverty* (1879). Both works were influenced by the struggles between the land barons and settlers in the early years of the state of California. His solution to speculation was to tax the unearned increment of land values. The land tax would return to society a portion of the increase in land value that it had created. Gates notes that, in 1976, another Californian, Carla Hills, then Secretary of Housing and Urban Development, supported the United Nations' Habitat position that land should be managed as a public resource rather than as a profit-generating commodity. George's land tax recommendations were a step in that direction.

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The ancillary force in the destiny of California's agriculture was water. The pattern of landholding was influenced by the dual system of water rights, and the conflicts arising out of doctrinal differences pertaining to public lands, mining, settlement, and the original grantees. The struggle for land was often a struggle for water. In 1902, the government sought to distribute the benefits of irrigation more widely through the Reclamation Act, to little avail. In this set of essays, Gates' approach to the water question is tangential. While he mentions some of the water issues, it is usually in the context of the overall landownership question.

How well do the laws and events of the mid-19th century explain resource and agricultural conditions in today's California? Gates makes no explicit claims, but the act of historical reporting is itself a claim to relevance. Certainly some of the concentration in landholdings of today can be linked to the earlier actions of Chapman, Miller and Lux, Haggin and others. But, if the message of recent developments in nonlinear dynamics is correct, then perhaps some insignificant little event during the gold rush may have produced an outcome totally different from anything we could imagine today. Who knows?

This set of essays, originally written for different publications at different times, contains some repetition, but it is an exceptionally rich source of background on California's agricultural landholding. While it cannot explain some of California's peculiar tax policies of recent years, it can suggest some origins of the present landownership and agricultural production patterns. Unless you are of the "history is bunk" school of economics, curl up with a copy of Gates' book for a few hours, and you will become wiser.

A Useful Reference on Policy

Policy For American Agriculture: Choices and Consequences. *First edition. By M.C. Hallberg. Ames, Iowa: Iowa State University Press, 1992, 374 pages.*

Reviewed by Sam Evans

This ambitious book by M.C. Hallberg is "aimed at providing the basic tools and information needed for future agricultural policy analysis and development." Nevertheless, the book is targeted to undergraduate students, presumably at the junior or senior level since there is emphasis throughout the book on standard techniques of welfare analysis. Hallberg believes the book could also serve as an introductory text in graduate-level courses on agricultural policy.

Hallberg's book contains a great deal of descriptive and historical information on income and price support programs for farm commodities. Thus, it may be a useful reference for anyone interested in learning more about the development and scope of U.S. agricultural policy. The book has a 20-page Appendix which provides a chronologial listing and brief summary of legislation having a major impact on U.S. agriculture. The listing begins with the Homestead Act of 1862 and ends with the Food, Agriculture, Conservation, and Trade Act of 1990. There is also a 28-page Glossary of farm program provisions, public and private institutions, and economic concepts related to agricultural policy and policy analysis. The Appendix, Glossary, and a well-thought-out Bibliography could be helpful for the experienced policy analysts as well as students and newcomers to the field.

Hallberg's book is divided into four sections: The Policy Environment; The Benefits And Costs of Farm Programs; Policy Analysis; and Prologue To The Future. The focus of the book is on compensation policy—income and price support programs. Consequently, about three-fourths of the book (sections 1 and 3) is devoted to descriptions and analyses of various supply control and demand expansion programs. There are, however, single chapters on trade policy and resource policy. The author does a workmanlike job throughout, but as might be expected in a book targeted to students, there is little new in content and presentation.

There are bound to be errors of commission and omission in a book that attempts to describe and analyze the broad array of U.S. farm programs. A substantive error of commission appears twice, on pages 28 and 352, where it is incorrectly stated that production from flexible acres is not eligible for nonrecourse of marketing loans. I also found Hallberg's estimates of commodity program costs confusing, even after his lengthy explanation of how they were calculated (chapter 5). The author does not rely on or cite USDA's "official" estimates of commodity program costs. Instead, he has made his own calculations. I would not make a point of this if the differences were small, but as an

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example of the differences, Hallberg estimates commodity program costs for fiscal 1986 at $43 billion, compared to USDA's estimate of $26 billion.

As for errors of omission, Hallberg, in my opinion, devotes too much space to historical programs and too little to the fundamental policy changes in the 1985 and 1990 U.S. farm legislation. Recent changes in policy are aimed at increasing market-orientation and export competitiveness and protecting the environment, and they reflect budget realities. These changes and why they were made are the best clues to policy choices for the future.

As an example, the Conservation Reserve Program receives only passing mention in the book. There are now 36 million acres of environmentally sensitive cropland enrolled in the CRP, including more than 10 million acres of wheat base (equivalent to a 15-percent acreage reduction for wheat). As CRP rental contracts begin to expire in 1996, this land may be returned to crop production or there may be Government incentives to keep it in conservation uses. Here, we have the potential for a classic policy confrontation, especially if export demand is strong, between production and environmental interests.

A Potpourri of Ideas on Undergraduate Education

Agriculture and the Undergraduate: Proceedings. *By the National Research Council, Board on Agriculture Staff. National Academic Press, 1992, 268 pages, $33.*

Reviewed by Neil E. Harl

The greatest contribution of most proceedings of conferences on undergraduate teaching is useful ideas for those concerned with resource allocation in academe and those involved directly with curriculum building. The modest volume ***Agriculture and the Undergraduate*** is no exception. The essays and the reports from discussion sessions at the 1991 conference from which the volume emanated provide a rich lode of insights, observations and experiences on ways to nudge the curriculum reform process. The volume is a potpourri of ideas on ways to improve undergraduate education. Some good. Some not so good. Some trivial. Some not so trivial. But all are deserving of careful thought and further reflection.

And yet the volume is laced with disturbing and troubling statements that deserve wider discussion than was received by this select group oriented heavily toward research in the physical and biological sciences.

A fundamental aspect of any effort at curriculum reform is the set of assumptions about employment challenges over the lifetime of graduates. One obvious component of that set of assumptions, at least for education related to a particular sector or subsector of the economy, is the direction likely to be taken by that sector or subsector over the next several decades.

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One cannot disagree seriously with the observation by Charles Hess in terms of education in agriculture. The period before the 1970s emphasized production agriculture. Moreover, one cannot fault his statement that educational patterns in the 1970s reflected a decided shift toward economics and business, and his observation that in the 1980s greater attention was given to the underlying sciences, especially the biological sciences. But what is not at all clear is that the 1980s' emphasis on science, particularly on biotechnology, will continue to be the polestar guiding curriculum reform in the 1990s and beyond. That is a message, occasionally explicit and nearly always implicit, throughout the volume.

One particularly notable passage is in the essay by Peter Spotts in which he states, "When I peel back all of the layers of the issues examined in this volume, I come away with a sense that, at its core, undergraduate education in science—be it in agriculture or any other field—must help students know that they are part of a larger community, one that extends beyond the bounds of a particular discipline or even of the sciences as a whole." While I agree with the basic premise of the statement that students need to gain appreciation for the greater world, I am appalled by the assumption apparent here and elsewhere in the volume *that agriculture is synonymous with science,* particularly when the context is *physical* science. Such an assumption demonstrates a misunderstanding of the difference between the many faceted sector known as agriculture with the physical sciences, social sciences, and the various disciplines in the humanities which contribute to that sector. The misconception evident in the view that agriculture is physical science is readily apparent if one were to reflect upon the sage advice and counsel that would likely have come

(and did) from similar conferences in the several decades dominated by production agriculture when agriculture was viewed as essentially the production of food and fiber and the only undergraduate education that really mattered was in the production disciplines.

Indeed, one audacious display of scientific paternalism was the startling statement that we should "reduce the use of the term *agriculture* because of its negative image." I repeat once again something that should be self-evident to anyone well short of being an undergraduate: agriculture and physical science are not synonymous. *Agriculture is not physical or biological science.*

While I know of no one who predicted accurately any of the shifts in curricular emphasis in agriculture over the past three quarters of a century, and I certainly doubt that I will mar that sterling record here, a good case can be made that the next major era of emphasis in agricultural education will be on management of information and management of resources in a world of rapidly changing technologies and gradually shifting policies. The skills needed by the graduates of our baccalaureate programs will go well beyond science and will include management, manipulation and analysis of information; the successful conduct of food production, processing and distribution operations within an increasingly constrained legal framework; and resource allocation (especially capital and labor) in a truly global competitive struggle. I would echo the observations of C. Eugene Allen in his assessment of the nature of the information management age.

A singular emphasis on science, especially the biological sciences, could well cripple U.S. agriculture. What the world does not need and could not long endure is a system of undergraduate education highly focused on the physical sciences to the point where everyone knows the difference between DNA and RNA and yet does not understand production function relationships or the configuration of a demand—supply curve.

Viewed through our own professional prisms, we tend to see a world deficient in those skills, abilities and understandings we know so well and take for granted. Economists have a certain disdain for their less-informed brethren who do not worship at the shrine of duality theory or even the subtleties of cross elasticity of demand. Lawyers recoil in horror at the thought that someone somewhere might not be able to recite the entire Bill of Rights and to maintain a learned discourse on each one. It is a bit disturbing that students—or even adults—do not fully comprehend plate tectonics. It is even more disturbing that undergraduate degree holders—at Harvard or anywhere else—do not understand the relationship among the sun, the earth and the seasons. But as Otto Doering so aptly notes, the fact is that we can never elevate the knowledge level of the general public to satisfy scientists. The malleable minds of the world are not some kind of intellectual clay to be shaped into our own professional image. The world has become too complex to expect all of our students to meet such a standard.

There is a place for physical and biological science in undergraduate education. It is my view that every undergraduate should be exposed to the power, the mysteries, the beauty and the rigor of science. And it is important for those who have the ability and the interest to continue in graduate education in the sciences to do so. I agree with Nils Hasselmo that students need to understand the basic nature of science. I am less sure of the validity of the assertion that each student needs to know something about the theory and methodology of at least one science. Realistically, that can probably be achieved only with major emphasis in a science. I feel a degree of intellectual discomfort with such a requirement.

To a considerable degree, our level of living in this country and our economic and physical security depend upon our level of cleverness. Without a technological edge, we can scarcely expect to maintain income levels well above the rest of the world. Education in the sciences is critical to our national future and, more fundamentally, is critical for the future of the human family.

But that does not mean that we should force every undergraduate through the same preparation that would assure an adequate base for graduate education in the sciences.

Agriculture is and should continue to be a many faceted, pluralistic sector with manifold educational needs and skill levels.

How, then, can we assure that those needs will be met?

In reading this volume of essays and group discussions, I am struck by the implicit acceptance of a planning model as individuals attempted to answer that question. Perhaps it is because of my recent educational work here and abroad with individuals from finance, banking, government, business and law in the transitioning economies of Central and Eastern Europe and the former Soviet Union that I have concerns about the efficacy of that model and the risks inherent in pursuing an

inclusive planning model. An approach to resource allocation based on planning often produces disappointing results and can be genuinely disastrous.

Higher education is producing, in a highly competitive environment, a collection of products in the form of educational experiences representing the faculty's best collective judgment of what will meet the needs of its students and what will be successful in the market. Even in the world of higher education, the consumer is king. Society has been, I believe, well served by a group of highly competitive institutions producing products with differing features and qualities. We cannot force feed a generation of students what they do not want and are unwilling to pay for. Sometimes we act as though we would like to wave a magic wand and force on our students our notions of a model or ideal curriculum. Sooner or later, students will obtain the collection of educational experiences they want. We are not entirely privileged to retire to monastic isolation and prescribe what we believe undergraduates should experience.

The last vestige of the student as captive may well disappear with the emergence of courses by satellite, permitting a degree of curriculum "merging" among institutions. Even with choice among institutions, once a student selected a particular institution the student tended to be a captive, at least for required courses. If students are free to select a course or courses by satellite from the leading intellectual light in a particular area, the student is even less a captive of the institution. Indeed, it seems likely that consumer choice among students will be an even greater factor as emerging technologies work in favor of student selection of course experiences and as economic pressures cause institutions to give greater attention to the marketability of their products.

What all of this adds up to is that we should be placing less emphasis on trying collectively to divine the intellectual configuration of society's needs and how we can meet those needs, and more emphasis on educational products to assist a student to develop uniquely in a world none of us can now very well know or understand.

A good case can be made that an individual completing work for an undergraduate degree should have gained the ability to think, to analyze and to reason and the ability to communicate orally, in writing and electronically. The former can be acquired in any good, rigorous curriculum that emphasizes the skills of critical thinking and analysis. As Karl Brandt noted, a college education should be about thinking. The latter is somewhat the responsibility of us all in academia, not merely those in language, speech and mass communication skill areas. Regrettably, we have perhaps not done as well in that area as we might.

In this regard, I am uneasy with reference throughout the volume to "professional" undergraduate education. It is a natural tendency to want to upgrade a product by renaming it. If what is meant by the use of the term "professional" is to encourage a higher level of critical self-evaluation, I have no quarrel with the use of the term. But I would have difficulty with the use of the term to the extent the use of "professional" is meant to connote a mastery of a part of the great body of knowledge sufficient to rank the individual among those who have achieved through post baccalaureate experience, education, training or some combination a level of performance signifying genuine mastery.

There seems to be little doubt that the curriculum should be the product of individual and collective faculty thought and debate. Ideas floated by an administration eager to capture the latest educational fad that are not subjected to the annealing heat of faculty debate are often doomed to failure or worse—misleading or misguiding a generation of students. There is no assurance that students will not occasionally be misled or misguided but the probabilities are lower if left in faculty hands.

The shortcomings of the best curriculum reform model are well known—(1) individual faculty members may thwart the reform process by continuing to teach the way they have been teaching (a type of conflict of interest on the part of faculty members), (2) the actual content of a course may not be known other than on a very general basis by faculty colleagues as peers so peer review is less than complete, (3) faculty may have a less than perfect perception of student needs, and (4) individual faculty may not be at the leading edge of even their own discipline and so may argue for and ultimately teach outdated concepts and ideas. These are all important problems and deserve attention. This volume focuses relatively less attention on these areas.

At the risk of appearing to be hopelessly provincial, I am moved to register surprise at the omission of law from the pantheon of disciplines involved in undergraduate education in agriculture. The failure to recognize the importance of the study of the legal or institutional framework within which resources are allocated and income is distributed is, in itself, surprising. But the absence of agricultural law in the chart by Norma Scott and Brian Chabot is jarring, particularly with the

listing of the "humanities" as a subject of "sciences" with specific mention of government, history and linguistics as the components of humanities.

Elsewhere, I have noted the major dimensions of the transition now occurring in U.S. agriculture: (1) a transition away from reliance on government price and income supports, (2) a transition toward greater reliance on the market, (3) a gradual demolition of trade barriers for food and fiber products and (4) increased concern about the impacts of agriculture on the environment (and the environment on agriculture) and increasingly restrictive policies as to food safety. In all of these areas, law is playing and is expected to continue to play an increasingly important role in production, processing and distribution operations. James Moseley alluded to this fact in reflecting upon the demands imposed upon him as assistant secretary of agriculture in USDA. But the need to know and understand the basics of the legal system goes well beyond undersecretaries of agriculture. Virtually everyone involved in agriculture in the twenty-first century will encounter the legal framework almost daily, from scientists to farmers.

A major concern in institutions of higher education involved with education in agriculture is the extent to which faculty in the agricultural side of disciplines are able to and do keep up with developments in the discipline generally. The argument is often heard that the agricultural side of disciplines, focusing on the applied rather than the theoretical, may fail to keep pace. Certainly this problem argues for strong efforts to encourage close intellectual linkages with individuals elsewhere on the campus functioning in the same core disciplines.

With concerns about arms control and national security receding from the international policy agenda, support for solving problems of food sufficiency, hunger and malnutrition; resource adjustment world-wide; and economic health of the food and fiber producing sector are moving to center stage. Far from diminishing in importance, issues relating to food production, processing and distribution appear likely to be poised for priority attention. Education to serve the diverse and complex agricultural sector is a topic worthy of debate and discussion. The volume reviewed makes a nice start in the direction of discussing undergraduate education *involving physical and biological science in agriculture.*

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